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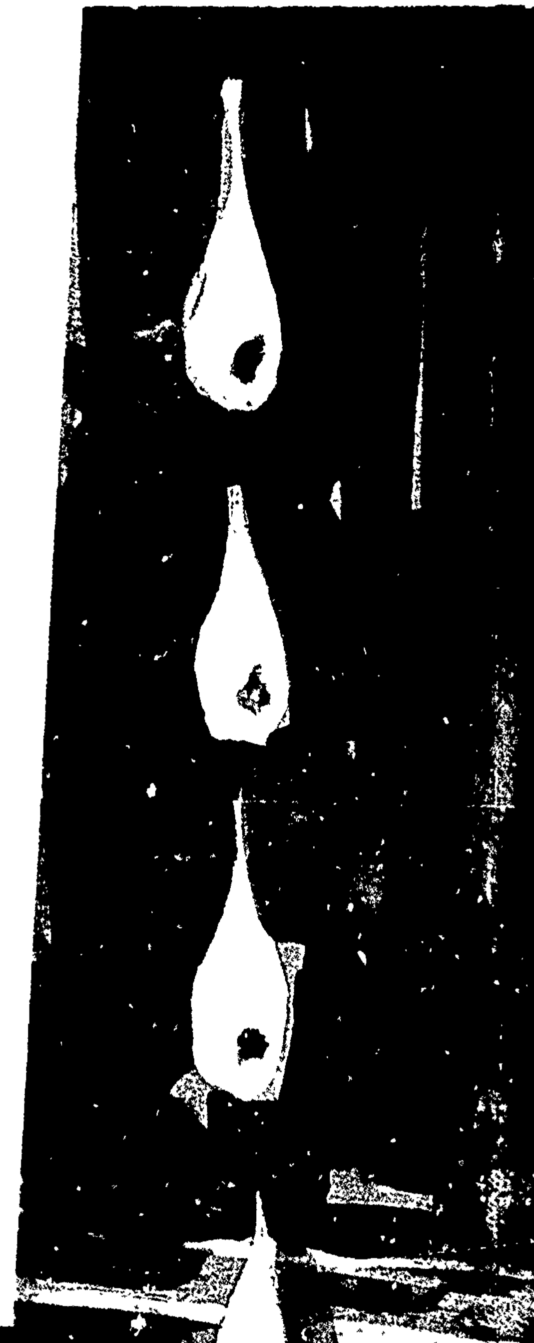
DELAWARE RIVER BASIN REPORT

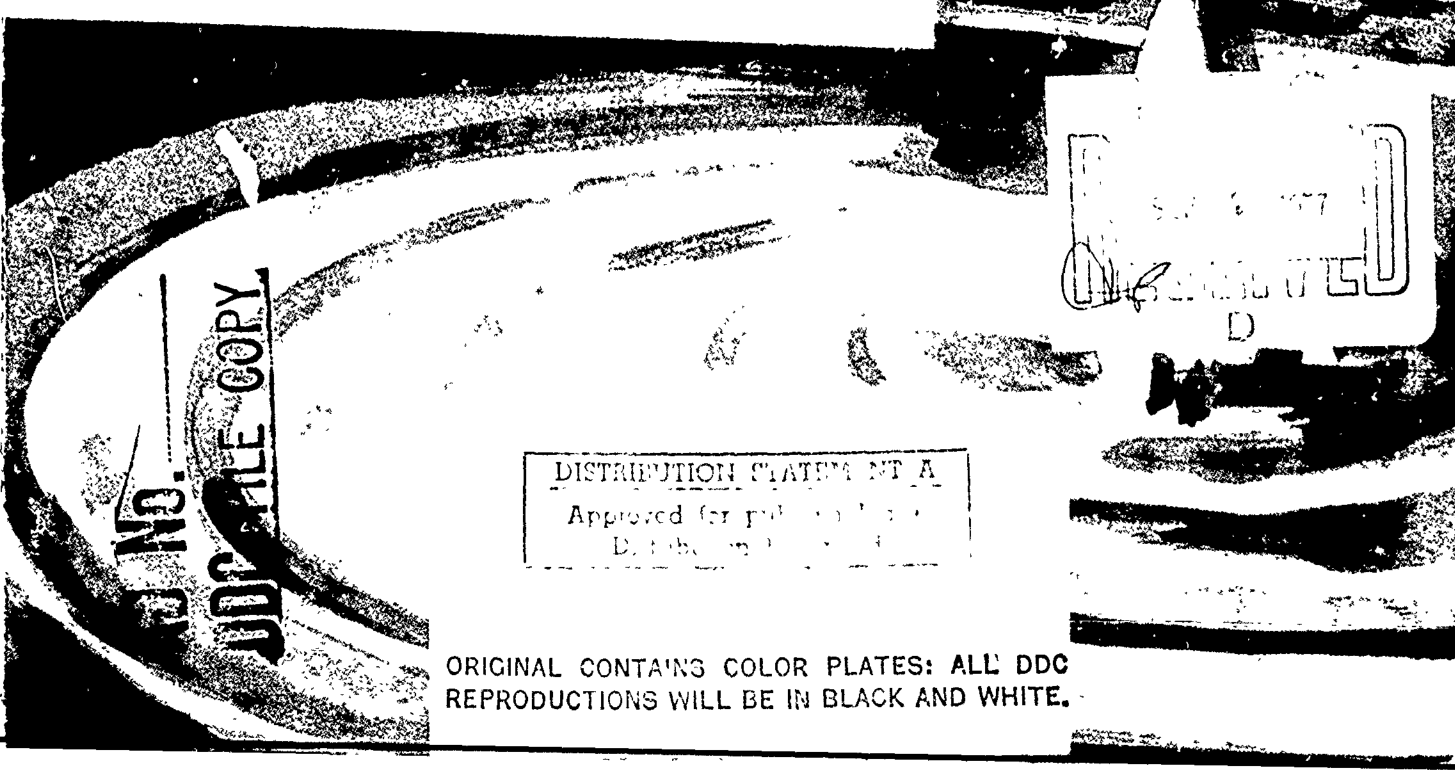
DEC. 1960

VOL. X

APPENDIX T. HYDROELECTRIC POWER

APPENDIX U PROJECT DESIGNS AND COST ESTIMATES





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REPORT ON THE

COMPREHENSIVE SURVEY

OF THE

WATER RESOURCES

OF THE

DELAWARE RIVER BASIN.

Volume X.

APPENDIX T and U.

HYDROELECTRIC POWER

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(Rev. Nov.1960)

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APPENDIX T - HYDROELECTRIC POWER

I INTRODUCTION

1. Development of hydroelectric power was included as a purpose to be considered in defining the plan for comprehensive development of the water resources of the Delaware River basin, in accordance with directives from the Congress. This appendix contains a review of hydroelectric power proposals in prior reports; describes the present power development in the area; discusses the need for additional hydroelectric power, describes briefly proposals for including hydroelectric power as a multiple purpose at projects in the comprehensive plan of development; and presents an evaluation of this potential hydroelectric power by the Federal Power Commission. The report on the power market study and the evaluation of hydroelectric power prepared by the Federal Power Commission, is contained in Appendix F POWER MARKETS AND VALUATION OF POWER.

II GEOGRAPHIC LIMITATIONS TO POWER DEVELOPMENT

2. Wide seasonal and annual streamflow fluctuations make it necessary to provide regulating storage if appreciable quantities of hydroelectric power are to be produced in Delaware River basin. Topographic and geologic conditions and cultural development along the principal streams in this basin make development of storage difficult and expensive. The topography is such that most tributary streams have relatively steep profiles and narrow flood plains. Few sites exist on tributaries where even moderate amounts of storage can be economically developed. The main stream profile is somewhat flatter than those of the tributaries but its flood plain is also relatively narrow. No major falls exist in the basin. The one wide, flat, valley in the basin is that along the lower section of Neversink River and Basher Kill. However, its contributing drainage area is relatively small and geologic conditions make construction of impounding structures difficult and prohibitively expensive. Extensive glaciation occurred over the Delaware River basin above Delaware Water Gap during the ice ages. This glaciation also extended over the upper portions of the Lehigh and the Schuylkill River basins and over the basins of the northern New Jersey tributaries. Old valleys were deepened by the glaciers and many of them refilled with a heterogeneous mass of glacial debris, oftentimes with depths ranging up to about 250 feet. This refill material presents difficult foundation conditions at most points along the Delaware River above the Delaware Water Gap. Below this point glacial melt water appears to have widened the river channel considerably beyond that required for present day runoff. Bends in the Delaware River and tributaries, with the exception of the "S"-shaped Wallpack Bend through Blue and Kittatinny Mountains, have wide angles and very moderate drops in river gradient around them. Many of these bends have developed around spurs composed largely of glacial deposits that are unsuited for saddle spillways, or for construction of diversion tunnels. These geologic conditions indicate that earthfill type dams, with either extensive foundation excavations or cutoff walls, would be advisable at most sites in the basin. Suitable rock foundations at reasonable depths are difficult to find for power plants and their lack has increased cost estimates for power development.

III LIMITATIONS DUE TO EXISTING IMPROVEMENTS

3. Development of storage sites in the Delaware River basin is further complicated by main line railroads that have been built in the flood plains of the Delaware River and its principal tributaries. Railroads extend along both banks of the Lehigh and the Schuylkill Rivers, and, except for about 43 miles between Delaware Water Gap and Port Jervis, along one bank or the other of the Delaware River. Major highways have also pre-empted portions of the flood plains, and numerous towns and villages have developed along many of the streams, often in potential storage areas. Topography outside the immediate stream valleys is generally rough, and broken by tributary stream valleys. Relocation of transport and other cultural developments in such terrain is difficult and expensive. Relocation costs are estimated to be so great in a number of cases as to render potential projects infeasible at this time.

4. An amended decree of the United States Supreme Court, dated 7 June 1954 (See Appendix A, Exhibit D), authorized the City of New York to divert 490 million gallons of water per day from the Delaware watershed after the completion of construction of and commencement of operation of the Neversink and Pepacton Reservoirs. This diversion may be increased to 800 million gallons per day upon completion (about 1962) of the Cannonsville Reservoir. The decree directed the use of the "Montague Formula" for determining low water releases to be made by the City of New York, under supervision of the Delaware River Master established under the decree. This formula requires that upon completion of the Neversink and Pepacton Reservoirs the City of New York shall release water from one or more of its reservoirs sufficient to maintain a minimum flow of 1,525 cubic feet per second in the Delaware River at Montague, New Jersey. After the completion of the Cannonsville Reservoir, releases must be increased to maintain a minimum flow of at least 1,750 cubic feet per second at this same point. The City of New York is also required to release as excess water, a quantity of water equal to 83 percent of the amount by which the estimated water consumption during the year is less than the City's estimate of the continuous safe yield without pumping, from all its sources, during the same year. These excess releases are required to begin on 15 June each year and continue as long as required to release the excess water, but in no event are excess releases to be made later than 15 March of the following year. The New York Board of Water Supply has indicated that water consumption is expected to equal, or exceed, the estimated safe continuous yield of the system by about the year 1980 and that no excess water releases will be made after that time. Water available for water supply and for use in hydroelectric power production was determined by preliminary reservoir operation studies which took into account the above provisions of the amended decree of 7 June 1954.

It was assumed in all cases that the diversions authorized under the decree would remain fully in force for the life of the projects and that the required minimum and excess releases would be available for water supply and hydroelectric power use. It was also assumed in detailed studies for the Hawk Mountain project, that releases for low flow regulation and of excess water would be made from the Pepacton Reservoir in the same proportion to the total releases required, that its estimated safe yield is to the combined safe yields of the three reservoirs operated by New York City.

5. The decree of 7 June 1954 also gave New Jersey the right to divert 100 million gallons of water per day from the basin without providing any compensating storage releases into Delaware River. A part of this diversion is now being made through the Delaware and Raritan Canal near Trenton, New Jersey, and future diversions are expected to be made by pumping from the Delaware River below the Tocks Island Project. Since these diversions are likely to occur downstream from all prospective power sites, no further consideration was given to these diversions in the investigations for hydroelectric power.

6. While the above diversions of water from the basin detract from the gross water available for multiple purpose uses in the basin, the development and use of compensating storage in connection with the New York City diversion projects has beneficial effects on low flows in the Delaware River. On the other hand, the storage facilities provided in connection with this diversion have pre-empted three desirable storage potentials in the upper portion of the basin.

Additional sites have also been pre-empted by hydroelectric power development at the Wallenpaupack site on Wallenpaupack Creek and at four sites in the Mongaup River basin.

IV REVIEW OF PRIOR INVESTIGATIONS

7. General

Development of hydroelectric power in the Delaware River basin has been the subject of, or given consideration in, a number of prior studies. Reports on this subject have been prepared at various times since 1911. These studies and reports have been prepared for privately-owned utility companies, state and interstate agencies, and for the Federal Government. They have covered individual projects, groups of projects in tributary basins, and projected plans for the Delaware River basin as a whole. Power development was one of the purposes included under provisions of House Document 308, 69th Congress, 2d Session in 1928, and was considered in each of the eight reports prepared for portions of the Delaware River basin. It has been reconsidered in later review reports on the Delaware and Lehigh Rivers. All available reports on power development in Delaware River basin have been reviewed in connection with this investigation and their power features summarized below. In these prior reports it was generally assumed that hydroelectric power would be produced in the Delaware River basin essentially as a by-product of the use of water resources for water supply, flow regulation, navigation, and other purposes. It was assumed in prior studies that the energy produced would be absorbed into existing public utility systems and a separate, or independent, transmission system for its distribution and marketing, would be unnecessary. It was also assumed in some cases, that existing utilities would either construct the power facilities and purchase water to operate them, or would lease and operate facilities constructed by state or interstate agencies.

8. Development of Shohola Creek

A project for development of hydroelectric power on Shohola and Pond Creeks in Pike County, Pennsylvania, was reported on by J. G. White, Consulting Engineers, in 1911. This appears to have been the first hydroelectric power project recommended for construction in the Delaware River basin. The report on this project proposed that a dam and storage reservoir be constructed on Shohola Creek above Shohola Falls; a regulating reservoir on Little Pond Creek, a tributary of adjacent Pond Creek; a diversion dam on Pond Creek and a power plant on Delaware River at Parkers Glen, Pennsylvania. Water would be conveyed by pipeline from the Shohola Falls storage reservoir, and by an open flume from the Pond Creek diversion dam, to the Little Pond Creek regulating reservoir. Steel penstocks would convey it from this point to the power plant. The storage reservoir would be about five miles long, and a 30-foot draw-down would provide about 69,000 acre-feet of storage. Four units, operating at about 546 feet of head, would provide a continuous power capacity of about 3,900 kilowatts and produce about 30 million kilowatt-hours of continuous energy annually. Development of this project was never undertaken.

9. Delaware River Regulation

The first basin-wide plan for regulation and conservation of Delaware River water resources was proposed in 1929 by Robert E. Horton, Consulting Engineer for the City of Trenton, New Jersey. The report on this plan concluded that flows in the Delaware River above Trenton, New Jersey, could best be regulated and conserved by constructing and operating a number of dams and reservoirs on this river and its tributaries. These would consist of: (a) three headwater storage reservoirs on the East and West Branches, Delaware River, above Hancock, New York, with a net usable capacity of about 945,000 acre-feet; (b) nine dams for storage and power development on Delaware River between Hancock and Port Jervis, New York, with storage regulation in connection with power development on Mongaup and Neversink Rivers, and Wallenpaupack and Shohola Creeks, providing a combined usable net volume of storage of about 472,000 acre-feet; (c) Wallpack Bend Reservoir on the Delaware River, with a usable storage of about 374,000 acre-feet; and (d) ten dams for power development, or power development and storage, on the Delaware River between Wallpack Bend Reservoir and Trenton, New Jersey, with a net usable volume of about 73,500 acre-feet. The total storage was estimated to be sufficient to provide a regulated flow of about 2,550 cubic feet per second at Hancock, New York; 3,800 at Port Jervis, New York; 6,500 at Easton, Pennsylvania (below the mouth of Lehigh River); and 6,600 cubic feet per second at Trenton, New Jersey. Regulated flows and available heads were estimated to be sufficient for the production of about 373,000 kilowatts of continuous power. Available pondage was estimated to be sufficient to produce about 600,000 kilowatts of power for a 10-hour period with a 40 percent load factor. The total cost of the plan was estimated in 1929 at $145,000,000. Revenues were estimated to be sufficient to pay a net return of 10 percent on the investment. The City of Trenton accepted the report but took no further action on it.

10. Power Investigations by the Corps of Engineers

Determination of the needs and possibilities for hydroelectric power development in the Delaware River basin was made a part of an investigation of water resources in this river in 1929. This investigation was authorized by the River and Harbor Act of 21 January 1927, under provisions of House Document No. 308, 69th Congress, 2d session, and was made by the U. S. Army Engineer District, Philadelphia. Reports on the investigations made under this authorization are published in the following Congressional documents, relating to the Delaware River and its tributaries:

Delaware River	-	H. Doc. 179, 73d Cong., 2d sess.
Lehigh River	-	H. Doc. 245, 72d Cong., 1st sess.
Shohola Creek	-	H. Doc. 155, 72d Cong., 1st sess.
Mongaup River	-	H. Doc. 660, 71st Cong., 3d sess.
Neversink River	-	H. Doc. 147, 72d Cong., 1st sess.
Tohickon Creek	-	H. Doc. 486, 71st Cong., 2d sess.
Neshaminy Creek	-	H. Doc. 429, 71st Cong., 2d sess.
Perkiomen Creek	-	H. Doc. 482, 71st Cong., 2d sess.

Review reports, submitted for the Lehigh River basin in 1944, and for the Delaware River basin in 1939 and 1946, gave further consideration to potential hydroelectric power development. The hydroelectric features considered in each of the above House Documents are summarized below.

11. Delaware River Basin. The Corps' report on this basin considered three power project groups. The first group included installations for power production at the Tocks Island, Belvidere, and Chestnut Hill dam sites on Delaware River. Development of these sites would have a total installed capacity of 176,000 kilowatts and would produce 689.2 million kilowatt-hours of energy annually. The cost of these installations was estimated in 1932 at $29,623,700. Average annual income was estimated at $12 per kilowatt of total installed capacity, or $2,112,000. The second group included the Cannonsville site on West Branch, Delaware River, and sites at Cochecton, Narrowsburg, Barryville, and Mongaup on the Delaware River, between Hancock and Port Jervis, New York, as well as the three sites included in the first group. The installed capacity for the second group would be 326,000 kilowatts and the annual production 1,148.4 million kilowatt-hours. The first cost of this group was estimated in 1932 at $46,754,600 and the annual revenue from power production, at $12 per installed kilowatt, at $3,912,000. Twelve storage reservoirs, located on tributaries of the Delaware River above Port Jervis, New York, were added to those in the second group, to be considered as a third group. These 12 storage reservoirs would have a total installed capacity of 61,000 K.W. These additional projects were reported as necessary to provide additional water supply for flow regulation, and sanitary and salinity control in the lower Delaware River. The report stated that a large and growing market existed for the power that might be produced on a peak power basis in the Delaware River basin and that this power should be worth about 8 mills per kilowatt-hour. The report considered the first two groups of projects feasible for development by private interests. It concluded that Federal participation at that time did not appear justifiable in any of the potential power developments considered. These conclusions were reviewed in 1939 and 1946 at the request of Congressional Committees, and the same conclusions were reached, except that it was found that the Wallpack Bend site on Delaware River might be developed later as a substitute for the Tocks Island site, if, and when, a need for upstream storage for water supply developed.

12. Lehigh River Basin. Only two sites were reported by the Corps of Engineers as favorable for development of hydroelectric power in the Lehigh River basin. Both of these were located on the Lehigh River in Carbon County, Pennsylvania, one just below the junction of Tobyhanna Creek and the other below the junction of Bear Creek. Two alternate projects were considered for development of these sites. The first proposal included construction of dams and power plants at both sites to develop 217 feet of head and 22,000 kilowatts of capacity at an estimated cost in 1931 of $5,326,500. Average annual energy produced would be 54.9 million kilowatt-hours at a cost of 10.2 mills per kilowatt-hour. The second proposal was for a dam on Lehigh River at the Tobyhanna site and a high level conduit about 18.5 miles long to a power plant located along the Lehigh River below the town of Jim Thorpe, Pennsylvania. Three small tributary reservoirs on Mud Run, Stony Creek, and Bear Creek, respectively, and along the line of this conduit, were proposed to provide increased flows and water regulation. The power plant would develop 942 feet of head, have an installed capacity of 103,200 kilowatts, and an annual energy production of 255.4 million kilowatt-hours. The estimated cost of the project in 1931 was $25,164,400 and the cost of annual energy production was 10.39 mills per kilowatt-hour. It was estimated that the power produced by either of these alternate schemes was worth only 8 mills per kilowatt-hour, and it was concluded that neither of these plans was economically feasible at that time. New preliminary investigations were made for these projects by the Federal Power Commission in 1944 in connection with flood control investigations of the Lehigh River basin. These investigations indicated that the power installation in the second proposal should be increased to 150,000 kilowatts and the project designed to develop a net head of from 1,000 to 1,100 feet. The report of that agency also suggested that it might be desirable to pump flood water collected in Bear Creek Reservoir, back into Tobyhanna Reservoir to produce additional power. No estimate was made of economic feasibility of power at that time.

13. Shohola Creek Basin. The report of the Corps of Engineers on this basin presented a plan to develop 630 feet of fall, or about 50 percent of the total on this stream for power. The plan included a reservoir at Shohola Falls and a smaller one near Cold Spring Lake, with a combined storage of about 27,000 acre-feet. The total installation would be 6,900 kilowatts, and would produce annually about 32 million kilowatt-hours of energy. The total cost of the installation was estimated in 1930 at $3,104,000, and annual operating costs at 10 percent, or $310,000. The cost of marketable energy was estimated at 10.8 mills per kilowatt-hour and its value at 8.0 mills. The project was concluded to be not justified at that time.

14. Mongaup River Basin. The existing development operated by the Rockland Light and Power Company in this basin and the Delaware project contemplated for later construction by that company are described in the Corps' report. The Delaware project would have a gross head of 160 feet, an installed capacity of 10,000 kilowatts, and an estimated annual energy output of 35 million kilowatt-hours. Since this plant was proposed for development by the private utility company, no estimate of cost, or benefit, was given.

15. Neversink River Basin. The report of the Corps of Engineers on this basin included a plan to develop the power from the water remaining after New York City was granted the right to divert water from this basin for its water supply needs. This plan included construction of dams and reservoirs at the Claryville, Denton Falls, Oakland Valley, and Woodburne sites on the Neversink River. These would have a combined storage capacity of 126,400 acre-feet, but 71,000 acre-feet of storage in Claryville was considered exclusively for diversion to New York City. The Denton Falls, Oakland Valley and Woodburne sites would develop a total of 835 feet of head and would have a combined installation of 22,500 kilowatts. It was estimated that they would produce annually about 48.7 million kilowatt-hours of continuous energy and about 9.4 million kilowatt-hours of interruptible energy. The first cost was estimated in 1931 at $11,245,000 and the annual charges at 10 percent, or $1,124,500. The cost of marketable energy would be about 21 mills per kilowatt-hour in the minimum year and about 18 mills in the average year. Since these costs were about three times those required for steam power generation, the plan was concluded not to be economically feasible at that time. The Godeffroy site on the lower Neversink River was also considered, but the report pointed out that the valley was nearly a mile wide at the site, and had a deep glacial fill on complex faults in ledge rock that made it practically impossible to construct a water-tight dam at this site. The cost of developing a net head of 70 feet at the Godeffroy site was estimated at about $20,000,000, and the cost of the energy that would be produced at about 150 mills per kilowatt-hour. It was concluded that the cost for developing this site was excessive.

16. Tohickon Creek Basin. One site without storage and three sites with limited storage were investigated by the Corps. The site without storage would produce about 12.4 million kilowatt-hours of energy per year at a first cost in 1929 of $1,101,000 and an annual charge of $121,000, or 9.7 mills per kilowatt-hour. The three sites with storage were estimated to produce about 25.7 million kilowatt-hours, at a first cost in 1929 of about $10,172,000 and annual charges of about $1,117,000, or about 40 mills per kilowatt-hour. The report concluded that the production of hydroelectric power on Tohickon Creek was prohibitively expensive.

17. Neshaminy Creek Basin. Two sites on this stream that had formerly been investigated as a part of an upland water supply for Philadelphia were considered by the Corps of Engineers for power development. These were estimated to produce only about 20 million kilowatt-hours of energy per year. The first cost was estimated in 1929 at about $15,477,000 and annual charges at 10 percent would be $1,548,000. The average cost of energy produced would be about 77 mills per kilowatt-hour. The report concluded that the development of hydroelectric power on Neshaminy Creek was not economically feasible at that time.

18. Perkiomen Creek Basin. Five projects to develop streamflow regulation and an average power head of 475 feet were considered by the Corps in this basin. These were estimated to produce about 30.2 million kilowatt-hours of energy annually. Annual interest charges, at 6 percent on the required investment, would result in this energy costing from 53 to 87 mills per kilowatt-hour. The report concluded that power development in Perkiomen Creek basin was prohibitively expensive.

19. Power Investigations by the City of Philadelphia

A Board of Consulting Engineers in 1945 and 1946 prepared a comprehensive report of potential upland sources for supplying water to the City of Philadelphia. The preliminary report on this survey, submitted in 1945, considered power installations in connection with water supply at the Wallpack Bend site on Delaware River; the Tobyhanna site on Lehigh River; and at the end of diversion tunnels carrying Lehigh River water into Pohopoco Reservoir on Pohopoco Creek. A small plant, of about 1,000 kilowatts, was also considered to utilize flows from a small regulating reservoir proposed on Shohola Creek. The installation proposed at Wallpack Bend would be 30,000 or 60,000 kilowatts, depending on the use of this reservoir for water supply storage. Water would be released through an average head of 75 feet and this water power privilege was estimated to be worth $100 per installed kilowatt to some advantageously situated power company. A power plant with an installation of 3,500 kilowatts would develop about 100 feet of head below Tobyhanna Dam on Lehigh River, and an installation of 40,000 kilowatts would develop about 700 feet of head, at the end of the Lehigh water diversion tunnels, where they would empty into Pohopoco Reservoir. The Board considered that these potential hydroelectric power installations constituted an asset to the water supply project, and stated that most of the facilities required, except the power plants themselves, would also be required for water supply. The Board estimated that this undeveloped power privilege would, at the time of construction of the water supply project, have a value to some favorably situated power company of perhaps $5,000,000. The final report submitted by the Board in 1946 estimated that the net head at the Wallpack Bend site would vary from 102 to 55 feet with an average productive head of 81 feet. An installation of 31,000 kilowatts at this plant would produce about 151.2 million kilowatt-hours of energy annually. The Board concluded that it was

reasonable to expect a favorably situated power company to pay the City of Philadelphia an annual rental of about $89,500 for this water power privilege but no further action has been taken.

20. Power Investigations by INCODEL

The Interstate Commission on the Delaware River Basin (INCODEL) issued a report in August 1950 that covered an investigation of the advisability of New York, New Jersey, and Pennsylvania constructing an "integrated" water supply system in the upper Delaware River Basin for their mutual use. Water supply was to be the principal use of the water in this basin, and several schemes were studied with this use in view. Dams were proposed on the West Branch of Delaware River at Cannonsville; the East Branch of Delaware River at Fishs Eddy; the Delaware River at Barryville and at Wallpack Bend; the Neversink River at Godeffroy; Flat Brook near its mouth; and Neshaminy Creek at Chalfont and Newtown. A regulating and storage reservoir for diverted Delaware River water would be constructed outside the Delaware River basin at Meyers Lake near Ramsey, New Jersey. The primary purpose of the proposed integrated water resources project was for water supply and stream flow regulation. Power development was considered to be of secondary importance but was included at those sites where water would be released for other purposes. The report proposed that all the power features be constructed for a public agency representing the Delaware basin States, and then leased and operated by privately-owned power companies. Power installations were considered as part of projects at Cannonsville, Barryville, Godeffroy, and Wallpack Bend and at Meyers Lake. The total installed capacity would be 56,130 kilowatts, based on maximum head, of which 22,200 kilowatts would be installed at Wallpack Bend. The available streamflow was estimated to be sufficient in the minimum year to use 15,420 kilowatts (based on minimum head) of this capacity for dependable power and 21,210 kilowatts (based on average head) for interruptible power. Use of this capacity would produce 135.1 million kilowatt-hours of primary energy and 186.2 million kilowatt-hours of secondary energy annually. The estimated cost in 1950 of the power installation was $8,795,000 and annual carrying charges at 6 percent would be $527,700. The annual value of power was estimated at $16.50 per kilowatt of dependable capacity and at 3.0 mills per kilowatt-hour of energy produced. This would provide a net revenue of $690,600 from continuous and interruptible power. No further action has been taken on this proposed development.

21. Power Investigations by the Commonwealth of Pennsylvania

Plans and cost estimates for the Wallpack Bend project on the Delaware River were prepared in 1955 by Albright & Friel, Inc., consulting engineers, for the Department of Forests and Waters, Commonwealth of Pennsylvania. This project was proposed to provide water

supply, stream flow regulation, and recreation for Pennsylvania and New Jersey. Studies indicated, however, that a substantial amount of hydroelectric power could be developed at this project from the water released for other purposes. The power features of the proposed project would be constructed and financed by a public agency and would be leased to and operated by privately-owned power companies. This arrangement, however, was not to preclude selling falling water to power companies so as to permit them to finance, construct and operate the power installation. An installation of 6,350 kilowatts was proposed to develop continuous power at Wallpack Bend. This installation was estimated to have a first cost of $1,300,000 and to produce 55.7 million kilowatt-hours of energy per year. The net annual value of this capacity and energy was estimated at $193,900. This value for power would be increased to $379,600 per year if the installation were increased to 22,200 kilowatts and the excess capacity used for producing interruptible power. The estimated capital cost of the larger power installation, based on 1955 prices, was $3,817,550.

22. Potential Power Estimates by Federal Power Commission

The Federal Power Commission compiled and published on 1 January 1953, a report entitled "Hydroelectric Power Resources of the United States." In this report the Commission estimated and assembled data on the undeveloped hydroelectric power resources of the principal river basins of the country by making use of data obtained during the course of comprehensive river basin surveys, made either in connection with the Commission's hydroelectric power project licensing work, or in cooperation with other Federal agencies and by other interests, public and private. The Commission's estimates of undeveloped water power were based on the rated capacity of generators that would normally be installed at the power sites, assuming reasonable regulation of flow by storage, with allowance for depletions by irrigation and other consumptive use, and on the assumption that each site would be developed to achieve, in conjunction with the development of other sites, the best overall development of the water resources of the basin for power and other multiple uses. The estimates of generation represented average annual generation of energy at these hydroelectric developments. The estimates included those projects for which economic feasibility had been demonstrated, as well as projects at sites where physical conditions indicated engineering feasibility and promise of economic feasibility some time in the future. The Federal Power Commission stated that the estimates of the latter class of projects are subject to revision, either by increase or decrease, as additional information becomes available concerning stream flow, reservoir sites, costs, and other pertinent factors. The projects in the Delaware River basin, included in these estimates, are listed in table T-1. This table lists 21 sites with a total head of 3,766 feet, an installed capacity of 999,900 kilowatts, and an estimated annual production of 2,739 million kilowatt-hours.

23. Tables T-2, T-3 and T-4 summarize the above estimates of hydroelectric power potential made in previous reports.

TABLE T-1

HYDROELECTRIC POWER POTENTIAL
UNDEVELOPED SITES - DELAWARE RIVER BASIN 1/

Name of Site	River	State	Installed Capacity kw.	Av. Ann. Energy mil. kw.-hr.	Gross Head ft.
Yardley	Delaware R.	N.J.-Pa.	60,000	290.0	45
Lumberville	Delaware R.	N.J.-Pa.	60,000	260.0	50
Riegelsville	Delaware R.	N.J.-Pa.	60,000	260.0	50
Mauch Chunk	Lehigh R.	Pa.	150,000	325.0	1,060
Chestnut Hill	Delaware R.	N.J.-Pa.	40,000	180.0	45
Belvidere	Delaware R.	N.J.-Pa.	170,000	450.0	120
Flat Brook	Flat Brook	N.J.	230,000	350.0	260
Wallpack Bend	Delaware R.	N.J.-Pa.	60,000	130.0	90
Oakland Valley	Neversink R.	N.Y.	9,700	46.0	210
Denton Falls	Neversink R.	N.Y.	14,900	67.0	360
Woodburne	Neversink R.	N.Y.	3,000	10.3	115
Delaware	Mongaup R.	N.Y.	10,000	35.0	160
Barryville	Delaware R.	N.Y.-Pa.	29,700	125.6	70
Wallenpaupack	Lackawaxen R.	Pa.	40,000	0.0	370
Narrowsburg	Delaware R.	N.Y.-Pa.	15,900	64.0	40
Hancock	E. Br. Del. R.	N.Y.	10,300	39.0	65
East Branch	E. Br. Del. R.	N.Y.	6,100	15.0	83
Lewbeach	Beaverkill	N.Y.	3,000	9.0	118
Livingston	Willowemoc Cr.	N.Y.	3,200	9.0	120
Cannonsville	W. Br. Del. R.	N.Y.	20,000	67.0	175
Delhi	Little Del. R.	N.Y.	4,100	7.3	160
		Total	999,900	2,739.2	3,766

1/ Source: Hydroelectric Power Resources of the United States - Developed and Undeveloped - 1953. Federal Power Commission, Washington, D. C.

TABLE T-2

HYDROELECTRIC POWER POTENTIAL
ASSOCIATED WITH DELAWARE RIVER REGULATION 1/

Name of Site	Stream	State	Installed Capacity 2/ kw.	Av. Ann. Energy mil. kw.-hr.	Aver. Net Head ft.
Hale Eddy	W.Br.Del. R.	N.Y.	5,680	18.5	34
Mile 166	W.Br.Del. R.	N.Y.	6,630	20.7	38
East Hancock	E.Br.Del. R.	N.Y.	58,860	128.1	131
Kellams Bridge	Delaware R.	Pa.-N.Y.	16,560	35.9	23
Callicoon	Delaware R.	Pa.-N.Y.	22,725	49.5	31
Skinners Falls	Delaware R.	Pa.-N.Y.	12,690	41.3	25
Narrowsburg	Delaware R.	Pa.-N.Y.	15,375	44.7	27
Tusten	Delaware R.	Pa.-N.Y.	21,555	46.9	28
Hawley	Wallenpaupack Cr.	Pa.	-	71.6	350
Barryville	Delaware R.	Pa.-N.Y.	49,770	108.2	55
Shohola	Shohola Cr.	Pa.	9,450	28.5	513
Pond Eddy	Delaware R.	Pa.-N.Y.	49,160	109.3	53
Mongaup	Delaware R.	Pa.-N.Y.	43,380	119.0	57
Mongaup River Proj.	Mongaup R.	N.Y.	-	92.8	752
Sparrowbush	Delaware R.	Pa.-N.Y.	31,455	76.9	34
Neversink River Proj.	Neversink R.	N.Y.	-	118.3	627
Wallpack	Delaware R.	Pa.-N.J.	115,500	251.3	82
Experiment Mills	Delaware R.	Pa.-N.J.	48,870	105.8	34
Belvidere	Delaware R.	Pa.-N.J.	52,650	154.7	48
Hutchinson	Delaware R.	Pa.-N.J.	38,100	101.2	31
Chestnut Hill	Delaware R.	Pa.-N.J.	37,860	91.9	28
Carpentersville	Delaware R.	Pa.-N.J.	34,800	100.6	26
Holland	Delaware R.	Pa.-N.J.	26,400	86.1	22
Frenchtown	Delaware R.	Pa.-N.J.	27,670	90.0	23
Tumble	Delaware R.	Pa.-N.J.	28,870	94.0	24
Lambertsville	Delaware R.	Pa.-N.J.	23,710	71.1	18
Scudders Falls	Delaware R.	Pa.-N.J.	31,320	79.1	20
	Total		809,040	2,336.0	3,134

1/ Source: Regulation and Conservation of the Delaware River - Robert E. Horton, Consulting Hydraulic Engineer, Albany, N.Y. February 1929.
2/ Installation based on a 40 percent assumed load factor.

TABLE T-3

HYDROELECTRIC POWER POTENTIAL
INVESTIGATIONS - DELAWARE RIVER BASIN 1/

Name of Site	Stream	State	Installed Capacity 2/ kw.	Av. Ann. Energy mil. kw.-hr.	Max. Oper. Head ft.
		DELAWARE RIVER BASIN			
GROUP I					
Tocks Island	Delaware R.	Pa.-N.J.	103,700	378.6	119
Belvidere	Delaware R.	Pa.-N.J.	43,000	181.7	47
Chestnut Hill	Delaware R.	Pa.-N.J.	29,700	128.9	32
	Total Group 1		176,400	689.2	198
GROUP 2					
Cannonsville	W.Br.Del. R.	N.Y.	25,800	57.8	135
Cohecton	Delaware R.	Pa.-N.Y.	6,100	30.8	23
Narrowsburg	Delaware R.	Pa.-N.Y.	10,600	54.2	38
Barryville	Delaware R.	Pa.-N.Y.	30,900	150.9	69
Mongaup	Delaware R.	Pa.-N.Y.	26,800	129.9	59
Tocks Island	Delaware R.	Pa.-N.J.	133,800	392.1	119
Belvidere	Delaware R.	Pa.-N.J.	54,800	194.1	47
Chestnut Hill	Delaware R.	Pa.-N.J.	37,800	138.6	32
	Total Group 2		326,000	1,148.4	522
GROUP 3					
Delhi	Little Del. R.	N.Y.	4,100	7.3	159
Cannonsville	W.Br. Del. R.	N.Y.	27,200	57.3	135
East Branch	E.Br. Del. R.	N.Y.	6,100	14.5	82
Lewbeach	Beaver Kill	N.Y.	3,000	8.7	117
Livingston Manor	Willowemoc Cr.	N.Y.	3,200	8.8	119
Hancock	E.Br. Del. R.	N.Y.	10,300	39.1	64
Callicoon	Calicoon Cr.	N.Y.	1,600	8.1	94
Cohecton	Delaware R.	Pa.-N.Y.	9,300	36.4	23
Narrowsburg	Delaware R.	Pa.-N.Y.	15,900	64.3	38
Prompton	W.Br. Lackawaxen R.	Pa.	1,000	3.8	69
Honesdale	Dyberry Cr.	Pa.	1,600	4.8	79
Barryville	Delaware R.	Pa.-N.Y.	29,700	125.6	69
Shohola Falls	Shohola Cr.	Pa.	5,200	14.7	254
Cold Spring	Shohola Cr.	Pa.	8,000	25.9	318

TABLE T-3 - Continued

HYDROELECTRIC POWER POTENTIAL
INVESTIGATIONS - DELAWARE RIVER BASIN 1/

Name of Site	Stream	State	Installed Capacity 2/ kw.	Av. Ann. Energy mil. kw.-hr.	Max. Oper. Head ft.
			DELAWARE RIVER BASIN - Continued		
GROUP 3 - Continued					
Mongaup	Delaware R.	Pa.-N.Y.	27,300	114.0	59
Woodbourne	Neversink R.	N.Y.	1,500	2.5	64
Denton Falls	Neversink R.	N.Y.	15,300	46.7	332
Tocks Island	Delaware R.	Pa.-N.J.	81,600	210.5	119
Belvidere	Delaware R.	Pa.-N.J.	34,200	112.2	47
Chestnut Hill	Delaware R.	Pa.-N.J.	23,800	82.0	32
	Total Group 3		309,900	987.2	2,273
			LEHIGH RIVER BASIN		
Tobyhanna	Lehigh R.	Pa.	22,000	54.9	73
Mauch Chunk	Lehigh R.	Pa.	103,200	255.4	942
	Total		125,200	310.3	1,015
			SHOHOLA CREEK BASIN		
Shohola Falls	Shohola Cr.	Pa.	2,770 3/	11.3	253
Cold Springs	Shohola Cr.	Pa.	4,880 3/	20.1	339
	Total		7,650 3/	31.4	592
			NEVERSINK RIVER BASIN		
Woodbourne	Neversink R.	N.Y.	750 4/	2.2	65
Denton Falls	Neversink R.	N.Y.	9,380 4/	35.3	360
Oakland Valley	Neversink R.	N.Y.	6,750 4/	24.9	210
	Total		16,880 4/	62.3	635

1/ Source: Reports submitted by U. S. Army Engineer District, Philadelphia under provisions of House Document No. 308, 69th Congress, 2d Session.
2/ Installation based on a 25 percent assumed load factor.
3/ Installation based on a 40 percent assumed load factor.
4/ Installation based on flow assumed available 20 percent of time.

TABLE T-4

HYDROELECTRIC POWER POTENTIAL
MISCELLANEOUS ESTIMATES - DELAWARE RIVER BASIN

Name of Site	Stream	State	Installed Capacity kw.	Aver. Ann. Energy mil. kw.-hr.	Max. Gross Head ft.	Estimated by	Date
Shohola Falls	Shohola Cr.	Pa.	12,000	30	643	J. G. White	1911
Shohola Falls	Shohola Cr.	Pa.	1,000	1/	1/	City of Phila.	1945
Tobyhanna	Lehigh R.	Pa.	3,500	1/	100	City of Phila.	1945
Pohopoco	Lehigh R.	Pa.	40,000	1/	700	City of Phila.	1945
Wallpack Bend	Del. R.	Pa.-N.J.	31,000	151.2	102	City of Phila.	1946
Wallpack Bend	Del. R.	Pa.-N.J.	22,200	116.0	95	INCODEL	1950
Wallpack Bend	Del. R.	Pa.-N.J.	22,200	168.0	95	Comm. of Pa.	1955
Cannonsville	W.Br.	N.Y.	12,500	42.4	153	INCODEL	1950
Barryville	Del. R.	Pa.-N.Y.	12,000	84.1	76.5	INCODEL	1950
Godeffroy	Neversink	N.Y.	2,250	15.8	155	INCODEL	1950
Meyers Lake	2/	N.J.	7,180	63.0	190	INCODEL	1950

1/ Not estimated.
2/ Outside Delaware Basin but would use diverted water.

V EXISTING HYDROELECTRIC POWER DEVELOPMENTS

24. Most of the electric energy used in the Delaware River basin is supplied by steam electric power plants constructed in this basin, or through interconnection with similar plants located in nearby areas. However, the Pennsylvania Power and Light Company owns and operates a 40,000-kilowatt hydroelectric power plant on Wallenpaupack Creek. The Orange and Rockland Utilities Company owns and operates four hydroelectric plants in the Mongaup River basin with a total capacity of about 26,000 kilowatts. Several manufacturing companies in New Jersey operate about 1,900 kilowatts of additional hydroelectric capacity, making a total of about 70,000 kilowatts of hydroelectric power installed in the basin. Delaware River basin water, diverted to supplement New York City's water supply, is, or will be used to generate hydroelectric power outside the basin. To use this water the Central Hudson Gas and Electric Company has installed a 25,000-kilowatt plant outside Delaware basin at Roundout Reservoir, on the end of the aqueduct from the Neversink River. The Orange and Rockland Utilities Company has installed a similar plant, with a capacity of 18,000 kilowatts, near the same location but on the aqueduct from Pepacton Reservoir. Both of these installations have been built and are operated by the respective utility companies under contracts with the New York City Board of Water Supply. A similar plant is under consideration at the Roundout Reservoir end of the Cannonsville Reservoir aqueduct now under construction. Four hydroelectric plants on the Susquehanna River (York Haven, Safe Harbor, Holtwood, and Conowingo), with a total installed capacity of 613,000 kilowatts, also supply hydroelectric energy to the utility systems serving the Delaware River basin.

VI EXISTING THERMAL POWER DEVELOPMENT

25. Power Supply Areas

The Federal Power Commission, in connection with its studies of the nation's electric power supply and requirements, has divided the country into 48 subareas designated as Power Supply Areas. Each of these consists of an area characterized by a considerable degree of interconnection and coordination among the electric utility systems operating therein. The power market area which most nearly coincides with the Delaware River Service Area, as defined in Appendix B, ECONOMIC BASE SURVEY, includes all of Power Supply Area 4 and about 70 percent of Power Supply Area 5. Power Supply Area 4 covers the southeastern portion of the State of New York, and includes Long Island and the City of New York. The portion of this area considered most likely to absorb the output of potential hydroelectric power projects in the upper portion of the Delaware River basin is the Service Area of the Interconnected System of the New York State Electric and Gas Corporation. It includes some 20 counties in central New York ranging from Sullivan County, in the east, to Erie County in the west. Power Supply Area 5 comprises all of New Jersey, Delaware, Eastern Pennsylvania, and parts of Maryland and Virginia and is the area considered most likely to absorb the power output of potential hydroelectric power projects in the lower portion of the basin.

26. Installed Capacity

The Interconnected System of the New York State Electric and Gas Corporation operates six steam electric plants, with an installed capacity of 594,000 kilowatts on 31 December 1957. These plants varied in size, with the largest being the Milliken Station at Cayuga Lake, New York, with an installed capacity at the end of 1959 of 305,000 kilowatts. There are 38 public utility systems in Power Supply Area 5 which operate power generating facilities. Of these, 13 are part of the Pennsylvania-New Jersey-Maryland Interconnection, and they account for 98 percent of all the power supply in the area. The installed steam electric capacity in Power Supply Area 5 was 9,363,591 kilowatts on 31 December 1957. The plants in this area vary in size from about 12,000 kilowatts capacity in the Lansdale Municipal System to the Burlington Plant of the Public Service Electric and Gas Company at Burlington, New Jersey, with an installed capacity of 490,000 kilowatts.

27. Energy Production

The energy requirements in the Interconnected System of the New York State Electric and Gas Corporation were about 3,178 million kilowatt-hours in 1958. The energy requirements in Power Supply Area 5 in 1957 were about

48.3 billion kilowatt-hours. About 94 percent of this energy was produced by steam electric plants and the remainder by water power and internal combustion engines.

28. Transmission Systems

The Delaware River basin is served by an extensive grid of interconnected power transmission lines. The general locations of the principal lines are shown on plate F-3 of Appendix F - POWER MARKETS AND VALUATION OF POWER. Although such lines are owned by several separate utility companies, various interconnection agreements are known to exist. In fact, the Pennsylvania-New Jersey-Maryland Interconnection covers all of this basin except the portion of New York State. Eight major electric light and power companies joined in a single power pool in 1956 to form and operate this interconnection. These companies and their installed capacities, as of 31 December 1957, are as follows:

	Kilowatts
Philadelphia Electric Company	2,348,250
Pennsylvania Power and Light Company	1,277,050
Public Service Electric and Gas Company	2,554,300
Metropolitan Edison Company	501,120
Pennsylvania Electric Company	906,567
New Jersey Power and Light Company	123,100
Jersey Central Power and Light Company	357,224
Baltimore Gas and Electric Company	955,500
TOTAL	9,023,111

This power pool serves some 48,000 square miles with an annual energy load of about 48 billion kilowatt-hours. Daily pool operations are controlled from a central dispatching office located in Philadelphia. Numerous small municipal and co-operative electric systems exist within the Delaware River Service Area. Pertinent data, furnished by the Federal Power Commission, on installed capacity, generation and purchases of those systems in Power Supply Area 5 is shown in table T-5.

TABLE T-5

MUNICIPAL AND RURAL COOPERATIVE ELECTRIC UTILITY SYSTEMS
IN THAT PORTION OF POWER SUPPLY AREA 5 WITHIN THE DELAWARE RIVER SERVICE AREA

State / Name of System	Generating Capacity I.C. kw.	Generating Capacity Steam kw.	Generating Capacity Hydro. kw.	Generating Capacity Total kw.	Total Net Generation 1,000's kw.-hr.	Purchases 1000's kw.-hr.	Energy for System 1,000's kw.-hr.	Supplier
DELAWARE								
Clayton Mun. Lt. & Water Dept.	-	-	-	-	-	1,609	1,609	Eastern Shore P. S. Co. of Maryland
Dover Municipal Power System	-	9,500	-	9,500	32,779	40,910	73,689	Delaware Power & Light Co.
Lewes Board of Public Works	3,438	-	-	3,438	7,410	3,691	11,101	Eastern Shore P. S. Co. of Maryland
Middletown Mun. Lt. & Water Dept.	-	-	-	-	-	4,154	4,154	Delaware Power & Light Co.
Milford Light & Water Dept.	-	-	-	-	-	19,620	19,620	Lincoln-Ellendale Electric Co.
New Castle Board of Wtr. & Lt. Comm.	-	-	-	-	-	5,546	5,546	Delaware Power & Light Co.
Seaford Municipal Electric System	5,302	-	-	5,302	15,422	-	15,422	-
Smyrna Light Department	-	-	-	-	-	7,207	7,207	Eastern Shore P. S. Co. of Maryland
Delaware Electric Coop.	-	-	-	-	-	42,445	42,445	Eastern Shore P. S. Co. of Maryland
Subtotal	8,740	9,500	-	18,240	55,611	125,182	180,793	
NEW JERSEY								
Butler Electric Light Dept.	-	-	-	-	-	19,162	19,162	Jersey Central Power & Light Co.
Lavallette, Boro of	-	-	-	-	-	2,734	2,734	Jersey Central Power & Light Co.
Madison Water & Light Dept.	-	-	-	-	-	21,392	21,392	Jersey Central Power & Light Co.
Milltown Boro Electric Dept.	-	-	-	-	-	12,137	12,137	Public Service Electric & Gas Co.
Park Ridge Electric Dept.	-	-	-	-	-	7,835	7,835	Orange & Rockland Utilities
Passaic Valley Water Comm.	-	-	2,400	2,400	9,917	-	8,123	-
Paterson, City of	-	5,500	3,680	9,180	21,508	-	11,685	-
Pemberton, Boro Electric Dept.	407	-	-	407	1,949	-	1,949	-
Seaside Heights Municipal Electric Dept.	-	-	-	-	-	5,203	5,203	Jersey Central Power & Light Co.
South River Board of Public Works	4,775	-	-	4,775	15,974	-	15,974	-
Sussex Rural Electric Coop.	-	-	-	-	-	7,411	7,411	New Jersey Power & Light Co.
Tri-County Rural Electric Coop.	-	-	-	-	-	9,430	9,430	Jersey Central Power & Light Co. (SOLD)
Subtotal	5,182	5,500	6,080	16,762	49,348	85,304	123,035	
PENNSYLVANIA								
Hatfield Boro Electric Light Co.	1,685	-	-	1,685	3,639	-	3,639	-
Kutztown Light & Power Co.	-	-	-	-	-	9,476	9,476	Metropolitan Edison
Lehighton Light & Power Dept.	-	-	-	-	-	12,709	12,709	Pennsylvania Power & Light
Perkasie Electric Light & Power	-	-	-	-	-	8,753	8,753	Pennsylvania Power & Light
Quakertown Electric Light Dept.	2,150	6,000	-	8,150	21,718	-	21,718	-
Schuylkill Haven Electric Dept.	-	-	-	-	-	14,194	14,194	Pennsylvania Power & Light
Saint Clair Boro. Electric Light Dept.	-	-	-	-	-	4,849	4,849	Pennsylvania Power & Light
Weatherly Boro Light & Power Plant	2,000	1,500	-	3,500	6,422	-	6,422	-
Subtotal	5,835	7,500	-	13,335	31,779	49,981	81,760	
TOTAL	19,757	22,500	6,080	48,337	136,738	260,467	385,588	

NOTES: 1. 1958 data
2. Excludes Lansdale, Pennsylvania, and Vineland, New Jersey municipal systems shown separately in Appendix F

VII NEED FOR ADDITIONAL POWER

29. The Federal Power Commission prepared estimates of future power requirements, as a part of this investigation. The methods employed and the results obtained are shown in Appendix F - POWER MARKETS AND VALUATION OF POWER. Table T-6 is a summary of the past and estimated future utility power requirements. It shows that the total energy supplied by the electric utilities in the Delaware River area amounted to 49 billion kilowatt-hours in 1955 and is expected to increase to about 180 billion kilowatt-hours by 1980 and to about 544 billion kilowatt-hours by 2010. The peak demand in 1955 was slightly more than 10 million kilowatts and it is estimated that it will increase to 34 million Kilowatts by 1980 and 96 million Kilowatts by 2010. It is apparent that to adequately serve this expected future load, present system capacities will have to be increased greatly through expansion of existing plants and/or construction of new stations. In meeting these increased demands local utility companies appear to have plans for only modest increase of their hydroelectric power capacities. The growing power market in this area would undoubtedly be able to readily absorb the output of all hydroelectric power plants that may be built on the Delaware River and its tributaries.

TABLE T-6

FUTURE UTILITY POWER REQUIREMENTS, 1950-2010
DELAWARE RIVER SERVICE AREA

Year	Total Energy for Load (Mil. kw.-hr.)	Peak Power Demand (Thous. kw.)	Average Load Factor (Percent)
1950 1/	35,028	7,403	54.1
1955 1/	49,027	10,145	55.2
1960	66,600	13,440	56.4
1965	88,100	17,490	57.5
1970	113,900	22,230	58.5
1975	114,500	27,720	59.5
1980	180,400	34,000	60.4
1985	222,100	41,500	61.3
1990	270,300	49,600	62.2
1995	325,700	59,000	63.0
2000	389,000	69,500	63.7
2005	461,200	82,000	64.3
2010	543,500	96,000	64.8

1/ Values shown for 1950 and 1955 are actual values. All other values have been estimated by the New York Regional Office of the Federal Power Commission.

VIII UNDEVELOPED HYDROELECTRIC POWER

30. Current Hydroelectric Power Estimates

Preliminary investigation of the water resources of the Delaware River basin indicated that there were 18 sites at which conventional type hydroelectric power installations might be feasible. A Power Work Group investigated the possibility of adding pumped storage at four of these sites and at one additional site. A local utility company has investigated an additional pumped storage project in the basin. Table T-7 lists the 20 sites at which the hydroelectric power potential has been investigated as a part of this comprehensive study. The locations of these sites are shown on plate T-1. Nine additional sites considered for multiple purpose development have also been investigated and are reported on in paragraph 81.

TABLE T-7
POTENTIAL HYDROELECTRIC POWER -
SITES INVESTIGATED - DELAWARE RIVER BASIN

Power Site	Stream	Miles Above Capes or Mouth	Type of Development
Hawk Mountain	E. Br. Del. R.	7.8	Storage
Hankins	Delaware R.	312.9	Run-of-river
Callicoon	Delaware R.	303.0	Run-of-river
Skinners Falls	Delaware R.	295.0	Run-of-river
Tusten	Delaware R.	285.0	Run-of-river
Knights Eddy	Delaware R.	263.4	Storage
Hawks Nest	Delaware R.	259.2	Run-of-river
Wallpack Bend	Delaware R.	226.0	Storage
Tocks Island	Delaware R.	217.4	Storage & Pumped Storage
Belvidere	Delaware R.	198.6	Run-of-river
Chestnut Hill	Delaware R.	185.9	Run-of-river
Holland	Delaware R.	170.9	Run-of-river
Eagle Island	Delaware R.	153.8	Run-of-river
Goat Hill	Delaware R.	147.3	Run-of-river
Lackawaxen	Lackawaxen R.	3.2	Storage
Shohola Falls	Shohola Cr.	9.1	Storage & Pumped Storage
Basher Kill	Neversink R.	2.3	Storage & Pumped Storage
Tobyhanna	Lehigh R.	81.4	Storage & Pumped Storage
Flat Brook	Flat Brook	-	Pumped Storage
Yards Creek	Yards Cr.	-	Pumped Storage

31. Preliminary Appraisal of Conventional Power Sites

Project formulation studies considered eight tentative plans, A thru H, each divided into two phases, for the development of the Delaware River water resources. Each plan was formulated as an integral group of projects to fully develop the water resources of the basin. Projects included in Phase I were those required for development prior to 1980 and projects included in Phase II were required in the period 1980-2010. (Phasing of projects was changed from plan to plan). A discussion of these plans is contained in Appendix Q - FORMATION OF PLAN OF DEVELOPMENT. Each of these tentative plans included one or more of the above potential power sites. Determination of the power costs and values at each of the above sites was required so that a comparative power evaluation could be considered for each of the tentative plans. Economic analysis of the large number of combinations of these plants in the eight tentative plans, required the use of a number of generalizations to permit early completion of this phase of the investigation. The size and type of power installation considered for each site and the average unit values for capacity and energy were selected after advisory conferences with representatives of the Federal Power Commission. A ninth plan, Plan K was subsequently considered at the request of the Federal Power Commission. This plan included only elements suggested for Phase I development and was composed primarily of potential pumped storage hydropower projects with added storage provisions as necessary for flood control and water supply. The pumped storage projects included in Plan K were referred to a Power Work Group for study and the findings of that group are reported herein.

32. Determination of capacity and energy. Water availability for hydroelectric power production was determined from the stream flow records of a selected 32-year stream flow period that included the water years 1923 to 1954, inclusive. These records were adjusted to reflect existing reservoir storage as well as existing and potential water diversions from the Delaware River Basin. Mass curves and flow-duration curves were developed for representative points in the basin. These curves were used to determine the gross minimum yield that would be available at each potential hydroelectric power site from the contributing drainage area as modified by proposed storage at the site and at upstream sites. Methods developed and used for determining water availability are described in Appendix M - HYDROLOGY. The flow values thus determined as available at each site were used in the preliminary appraisal to determine plant capacity for all peak power installations. Preliminary operation studies were used to determine similar values for plants considered in the final plan. A load factor of 20 percent and an overall plant efficiency of 85 percent were used in selecting the installed capacities. Average usable flows for determining average annual energy values were obtained from analyses of flow duration curves and the generalized curves shown on plate T-2. The characteristics of the power facilities selected for development at each site are presented in subsequent paragraphs.

33. Determination of cost of power facilities.

Preliminary layouts, designs and cost estimates were prepared for the power facilities selected for each site. Estimates of costs for the power plants, including their hydraulic and electrical equipment, were determined from generalized cost curves prepared by the Federal Power Commission from average costs for existing hydroelectric installations. These curves are shown on plate T-3. Cost estimates for the intakes, waterways and outlet facilities were prepared in the office of the U. S. Army Engineer District, Philadelphia. The construction period was taken as four years for each site and interest on the amount of the increasing investment in each year was assumed to be 2-1/2 percent per year for two years. For determination of annual charges in the preliminary investigations interest, amortization, and interim replacement charges were taken as 5 percent of the investment for power facilities. This figure was based on a low-risk interest rate and was considered sufficiently conservative for use in the preliminary investigations. Operation and maintenance charges for the power facilities were taken from the curve on plate T-4 which shows an average relationship determined by the Federal Power Commission 1/ between these annual charges per installed kilowatt and the size of the installation. The charge for administration and general expenses was estimated at thirty-five percent of the operation and maintenance charge recommended by Federal Power Commission.1/ First costs and annual charges for the power features, at each site in the several plans, are shown in paragraphs describing the sites.

1/ Federal Power Commission - Instructions for Estimating Electric Power Costs and Values, Bureau of Power, Technical Memorandum No. 1, Washington 25, D. C., 7 May 1958.

34. Determination of Costs of Dams and Reservoirs. Studies to determine the cost of including hydropower at prospective multiple-purpose projects included the specific power facility costs only. Specific costs are the costs of project features normally serving only one specific project purpose. These costs are taken as the total cost of identifiable project features. Those projects which were considered as single-purpose projects for power only, such as the run-of-river sites, were charged with the entire cost of dam and reservoir, as well as the costs for power facilities. Preliminary layouts, designs and estimates were prepared for the dams and reservoirs. Interest during construction was taken as the same as that for power facilities. Interest, amortization and interim replacement charges were taken as 4 percent of the investment. Operation and maintenance charges for dams and reservoirs were determined from plate T-5, which shows the average general relationship determined in this investigation between annual costs and the first cost of these features (no power costs included).

35. Determination of Power Benefits. The capacity and energy values for the power produced at these potential sites were determined in preliminary power valuation studies made by the Federal Power Commission. The unit values selected represent the average cost of producing equivalent amounts of power and energy by alternative construction and operation of steam electric plants in this area. These preliminary studies showed the average annual value of capacity to be $27.55 per kilowatt, and the average annual value of the energy produced to be 3.32 mills per kilowatt-hour. These average annual values were used at all of the sites investigated to determine the value of the power that would be produced. For the preliminary investigations, dependable capacity was evaluated on the basis of average head. The power value and the preliminary benefit-cost relationship based on specific power costs determined for each site are shown in tables T-8 and T-9. The subsequent paragraphs describe each individual site.

36. For these preliminary investigations of prospective power sites, the evaluation has been based upon the cost and value of wer at the low-tension bus bars for both the hydroelectric plants and the alternative steam plants. Designs and estimates for switchyards and transmission systems have been omitted from these preliminary investigations.

TABLE T-8
DELAWARE RIVER SURVEY
PRELIMINARY APPRAISAL OF POWER SITES
PROJECT DATA

Project:	Hawk Mtn.	Mankins	Callicoon	Skinners Falls	Tusten	Knights Eddy	Hawks Nest	Wallpack Bend	Tocks Island
Type of Development:	Storage	Run-of-river	Run-of-river	Run-of-river	Run-of-river	Storage	Run-of-river Plan A-I	Storage Plan D-II	Storage Plan A-I
Location, river	East Branch, Del. R.	Delaware	Delaware	Delaware	Delaware	Delaware	Delaware	Delaware	Delaware
Location, miles above mouth or Delaware Capes	7.8	313.0	303.0	295.0	285.0	263.4	259.2	226.0	217.4
Drainage area, sq. mi.	440 (a)	823 (b)	887 (b)	1,079 (b)	1,156 (b)	2,011 (b)	2,224 (b)	2,820 (d)	2,912 (d)
Reservoir elev., feet, m.s.l.									
Max. flood control	-	-	-	-	-	793	-	-	420
Max. power pool	1,082	822	774	730	680	773	508	420	395
Min. power pool	950	-	-	-	-	602	-	352	334
Storage capacity, acre-ft.									
Flood control	0	0	0	0	0	270,000	-	0	300,000
Power	290,000	0	0	0	0	1,200,000	0	352,000	315,000
Total (j)	293,000	3,500	13,000	11,000	6,900	1,570,000	13,000	372,000	635,000
Average tailwater elev.	930	780	730	690	640	495	450	325	300
Net head, max., feet	152	42	44	40	40	278	58	95	95
, min., feet	20	0+(f)	0+(f)	0+(f)	0+(f)	107	0+(f)	27	34
, average, feet	108	42	44	40	40	221	58	72	75
Regulated flow, c.f.s.									
Critical period	800	930	945	975	985	3,000	1,160	3,935	2,030
Average for power	1,180	2,200	2,290	2,560	2,660	4,300	4,540	5,830	5,300
Power									
Installed capacity, kw.	31,200	14,000	15,000	14,100	14,200	239,000 (c)	19,700	102,000	55,000
Dependable capacity, kw. (e)	31,200	14,000	15,000	14,100	14,200	239,000 (c)	4,850	102,000	55,000
Primary energy, kw.-hr.	53,800,000	24,300,000	25,900,000	24,300,000	24,500,000	413,000,000 (c)	41,900,000	176,000,000	94,800,000
Average annual energy, kw.-hr.	79,400,000	57,600,000	62,800,000	63,800,000	66,300,000	592,000,000 (c)	164,000,000	261,500,000	247,600,000
Load factor in critical period, %	20	20	20	20	20	20	100	20	20

TABLE T-8
DELAWARE RIVER SURVEY
PRELIMINARY APPRAISAL OF POWER SITES
PROJECT DATA

Project:	Belvidere	Chestnut Hill	Holland	Eagle Island	Goat Hill	Lackawaxen	Shohola Falls	Basher Kill	Tobyhanna
Type of Development:	Run-of-river Plan A-I	Run-of-river Plan A-I	Run-of-river Plan A-I	Run-of-river Plan A-I	Run-of-river Plan A-I	Storage Plan F	Storage & Pumped Stor.	Storage & Pumped Stor.	Storage & Pumped Stor.
Location, river	Delaware	Delaware	Delaware	Delaware	Delaware	Lackawaxen	Shohola Cr.	Neversink R.	Lehigh R.
Location, miles above mouth or Delaware Capes	198.6	185.9	170.9	153.8	147.3	3.2	9.1	4.0	81.4
Drainage area, sq. mi.	3,450 (d)	3,725 (d)	5,442 (d)	5,712 (d)	5,777 (d)	595 (g)	57	233 (h)	224
Reservoir elev., feet, m.s.l.									
Max. flood control	-	-	-	-	-	862	1,181	0	0
Max. power pool	280	200	140	85	60	808	1,166	562	1,530
Min. power pool	-	-	-	-	-	708	1,145	440	1,424
Storage capacity, acre-ft.									
Flood control	-	-	-	-	-	80,000	20,000	-	-
Power	-	0	0	0	0	60,000	18,000	640,000	85,000
Total (j)	31,000	11,000	5,300	4,000	4,700	143,000	40,000	648,000	87,000
Average tailwater elev.	235	157	100	60	42	620	550	420	500
Net head, max., feet	45	43	40	25	18	178	586	142	990
, min., feet	0+(f)	0+(f)	0+(f)	0+(f)	0+(f)	88	565±	20	884
, average, (e)	45	43	40	25	18	145	579	100	955
Regulated flow, c.f.s.									
Critical period	2,120	2,165	3,460	3,540	3,560	240	50	830 (i)	255
Average for power	6,370	6,240	9,870	10,450	10,510	790	95	830	440
Power									
Installed capacity, kw.	34,400	23,200	30,400	19,900	14,400	12,500	10,500	30,000	88,000
Dependable capacity, kw.	34,400	6,700	10,000	6,400	4,600	12,500	10,500	30,000	88,000
Primary energy, kw.-hr.	59,400,000	58,000,000	86,200,000	55,100,000	39,900,000	21,700,000	18,000,000	51,700,000	151,700,000
Average annual energy, kw.-hr.	178,500,000	167,100,000	245,900,000	162,700,000	117,800,000	71,400,000	33,900,000	51,700,000	263,500,000
Load factor in critical period, %	20	100	100	100	100	20	20	20	20

(a) Excludes 373 sq. miles above Downsville dam that contributes to Pepacton Reservoir (N.Y.C. water supply).
(b) Excludes drainage area above Downsville and Cannonsville dams (N.Y.C. water supply).
(c) Does not include power at Hawks Nest which is considered a necessary reregulator.
(d) Excludes drainage area above Downsville, Cannonsville and Neversink dams (N.Y.C. water supply).
(e) For preliminary estimates, dependable capacity was computed on basis of water available during critical period and average head during critical period.
(f) Approximately zero during high floods due to submergence.
(g) Includes 228 sq. mi. controlled by Wallenpaupack.
(h) Excludes 93 sq. mi. above Neversink Reservoir (N.Y.C. water supply)
(i) Includes 350 c.f.s. pumped from Delaware R.
(j) Includes flood control, power and inactive storage.

Sheet 1 of 2

TABLE T-9
DELAWARE RIVER SURVEY
PRELIMINARY APPRAISAL OF POWER SITES
ECONOMIC DATA

PROJECT:	Hawk Mtn.	Hankins	Callicoon	Skinners Falls	Tusten	Knights Eddy	Hawks Nest Plan A-I	Wallpack Bend Plan D-II	Tocks Island Plan A-I
Construction cost	$16,102,000(a)	$35,760,000(b)	$19,693,000(b)	$16,717,000(b)	$20,361,000(b)	$57,656,000(c)	$22,746,000(b)	$25,365,000(a)	$24,330,000(a)
Interest during construction	805,000	1,788,000	984,000	837,000	1,018,000	2,883,000	1,137,000	1,268,000	1,216,000
Investment for power	16,907,000(a)	37,548,000(b)	20,677,000(b)	17,554,000(b)	21,379,000(b)	60,539,000(c)	23,883,000(b)	26,633,000(a)	25,546,000(a)
Average annual charges (g)									
Interest, Amortization, & Major Replacements	846,000	1,570,000	885,000	761,000	948,000	2,854,000	1,021,000	1,332,000	1,277,000
Operation and maintenance	143,000	160,000	148,000	138,000	145,000	716,000	161,000	275,000	190,000
Total	989,000(a)	1,730,000(b)	1,033,000(b)	899,000(b)	1,093,000(b)	3,570,000(c)	1,182,000(b)	1,607,000(a)	1,467,000(a)
Average annual benefits									
Dep. capacity at $27.55/kw.	859,000	385,000	413,000	388,000	391,000	6,590,000	134,000	2,810,000	1,515,000
Energy at 3.32 mills/kw.-hr.	264,000	191,000	208,000	212,000	220,000	1,965,000	544,000	868,000	822,000
Total	1,123,000	576,000	621,000	600,000	611,000	9,268,000(d)	678,000	3,678,000	2,337,000
Average annual net benefit	134,000	-1,154,000	-412,000	-299,000	-482,000	5,698,000(c)	-504,000	2,071,000	870,000

TABLE T-9
DELAWARE RIVER SURVEY
PRELIMINARY APPRAISAL OF POWER SITES
ECONOMIC DATA

PROJECT:	Belvidere Plan A-I	Chestnut Hill Plan A-I	Holland Plan A-I	Eagle Island Plan A-I	Goat Hill Plan A-I	Lackawaxen Plan F	Shohola Falls Plan D & G	Basher Kill Plan E(h)	Tobyhanna Plan A,B,D,E,H(i)
Construction cost	$32,150,000(b)	$27,670,000(b)	$28,384,000(b)	$23,344,000(b)	$19,805,000(b)	$5,380,000(a)	$6,490,000(a)	$35,857,000(a)	$66,870,000(a)
Interest during construction	1,607,000	1,384,000	1,419,000	1,167,000	990,000	269,000	324,000	1,793,000	3,344,000
Investment for power	33,757,000(b)	29,054,000(b)	29,803,000(b)	24,511,000(b)	20,795,000(b)	5,649,000(a)	6,814,000(a)	37,650,000(a)	70,214,000(a)
Average annual charges (g)									
Interest, Amortization, & Major Replacements	1,523,000	1,264,000	1,312,000	1,090,000	932,000	282,000	341,000	1,882,000	3,511,000
Operation and maintenance	197,000	173,000	193,000	159,000	135,000	90,000	82,000	135,000	255,000
Total	1,720,000(b)	1,437,000(b)	1,505,000(b)	1,249,000(b)	1,067,000(b)	372,000(a)	423,000(a)	2,017,000(a)	3,766,000(a)
Average annual benefits									
Dep. capacity at $27.55/kw.	948,000	184,500	275,500	176,000	126,800	344,000	289,000	826,000	2,424,000
Energy at 3.32 mills/kw.-hr.	593,000	555,000	816,500	540,000	391,000	237,000	112,500	172,000	875,000
Total	1,541,000	739,500	1,092,000	716,000	517,800	581,000	401,500	998,000	3,299,000
Average annual net benefits	-179,000(e)	-697,500	-413,000	-533,000	-549,200	209,000	-21,500	-1,019,000	-467,000
Maximum net benefits	-101,000(in Plan D-II)	-474,000 (in Plan D-II)	-160,000 (in Plan D-II)	-376,000 (in Plan D-II)	-437,400 (in Plan D-II)				
Other net benefits							-980,000 (in Plan K) (j)(a)	-6,034,000 (in Plan K) (j)(a)	-2,919,000 (in Plan K) (j)(a)

(a) Power facilities only (i.e., dam and reservoir excluded).
(b) Entire project including dam, reservoir, and powerhouse.
(c) Includes power facilities at Knights Eddy and reregulating dam at Hawks Nest. Does not include cost of dam and reservoir at Knights Eddy.
(d) Includes value of power at Hawks Nest.
(e) Reregulation by Chestnut Hill required.
(f) 228 sq. mi. controlled by Wallenpaupack.
(g) Interest, amortization and interim replacement charges were taken as 5 percent for power facilities. Interest and amortization charges were taken as 4 percent for dams and reservoirs. O&M charges are from plates T-4 and T-5.
(h) Also in Plan F and G.
(i) Also in Plan F.
(j) Power Work Group Study for pumped storage plant. (Based on private financing)

37. Hawk Mountain Site. This site is located on East Branch, Delaware River, in Delaware County, New York, about 7.8 miles above the mouth of this tributary. It was selected after consideration of the East Branch site, and the Hancock site in the same vicinity on this stream. The contributing drainage is 440 square miles, exclusive of 373 square miles above Downsville Dam, that contributes to Pepacton Reservoir, a part of New York City's water supply system. This site would be developed for a dual-purpose project for water supply and hydroelectric power under Plans A, B, C, D, and H by constructing an earth fill type dam to form a reservoir with a maximum pool at elevation 1,082; average tailwater below the dam would be at elevation 930 under each of the five plans. Hydroelectric power would be produced at this site by the water stored and released for water supply. Tables T-8 and T-9 show the principal characteristics, as well as the costs and benefits, associated with this project. Table T-9 also indicates that hydroelectric power production at the Hawk Mountain site would be economically feasible and this site was selected for more detailed investigation.

38. Hankins Site. This site is located on Delaware River about 313 miles above the Delaware Capes, and about 18 miles below the junction of the East and West Branches at Hancock, New York. The site is situated in Delaware County, New York, and Wayne County, Pennsylvania, and was selected after consideration of a number of other sites in this vicinity. The contributing drainage area below the Hawk Mountain site on East Branch Delaware River and the Cannonsville site on West Branch Delaware River, is 383 square miles. This site was considered as a run-of-river development in Plans A, B, C, E, and H to utilize the regulated flows provided by long term storage at the Hawk Mountain site. The site would be developed under each plan by constructing a concrete weir surmounted by crest gates across the Delaware River. The full pool level would be restricted to elevation 822 by the main line of the Erie Railroad, which runs throughout the length of the reservoir. Average tailwater is estimated at elevation 780. Peaking power would be produced at this site by synchronizing its operation with that at Hawk Mountain. Tables T-8 and T-9 show the principal characteristics, as well as the costs and benefits, associated with this project. The results of the preliminary appraisal, as shown in table T-9 ,indicate that it would not be economically feasible to produce hydroelectric power at the Hankins site and no further consideration was given toward developing this site.

39. Callicoon Site. This site is located on Delaware River in Sullivan County, New York, and Wayne County, Pennsylvania, about 303 miles above the Delaware Capes. It was selected after consideration of the Cochecton site and other sites in this reach of Delaware River. The additional contributing drainage area between the Hankins Site and the Callicoon Site is 64 square miles. This site was considered as a run-of-river development in Plans A, B, C, E, and H to utilize the

regulated flows provided by long term storage at the Hawk Mountain site. The site would be developed under each plan by constructing a concrete weir surmounted by crest gates across the Delaware River. The main line of the Erie Railroad follows the river in this reach and limits the pool elevation of the Callicoon site to 774 feet. Average tailwater is estimated at elevation 730. Peaking power would be produced at this site by synchronizing its operation with that at Hawk Mountain. Tables T-8 and T-9 show the principal characteristics, as well as the costs and benefits, associated with this project. The results of the preliminary appraisal shown in table T-9 indicate that it would not be economically feasible to produce hydroelectric power at the Callicoon site and no further consideration was given toward developing this site.

40. Skinners Falls Site. This site is located on the Delaware River in Sullivan County, New York, and Wayne County, Pennsylvania, about 295 miles from the Delaware Capes. It was selected after consideration of the Narrowsburg and Cochecton sites and other potential sites in this reach of the river. The additional contributing drainage area between this site and Callicoon site is 192 square miles. This site was considered as a run-of-river development in Plans A, B, C, E, and H to utilize the regulated flow provided by long term storage at the Hawk Mountain site. The site would be developed by constructing a concrete weir surmounted by crest gates across the Delaware River. The main line of the Erie Railroad follows the river in this reach and limits pool elevation of the Skinners Falls site to 730 feet. Average tailwater is estimated at elevation 690. Peaking power would be produced at this site by synchronizing its operation with that of Hawk Mountain. Tables T-8 and T-9 show the principal characteristics, as well as the costs and benefits, associated with this project. The results of the preliminary appraisal, as shown in table T-9, indicate that it would not be feasible to develop hydroelectric power at this site and no further consideration was given toward its development.

41. Tusten Site. This site is located on Delaware River in Sullivan County, New York, and Pike County, Pennsylvania, about 285 miles above the Delaware Capes. It was selected after consideration of the Narrowsburg site and other sites in this reach of the Delaware River. The additional contributing drainage area between the Skinners Falls site and the Tusten site is 77 square miles. This site was considered as a run-of-river development in Plans A, B, C, E, and H, to utilize regulated flow provided by long term storage at the Hawk Mountain site. The site would be developed by constructing a concrete weir surmounted by crest gates across the Delaware River. The main line of the Erie Railroad follows the river in this reach and limits the pool elevation at the Tusten site to 680 feet. Average tailwater is estimated at elevation 640, providing a gross head of 40 feet for power production. Peaking power would be produced at this site by synchronizing its operation with that at Hawk Mountain. Tables T-8 and T-9 show the principal characteristics, as well as the costs and benefits, associated with this project. The results of the preliminary appraisal

shown in Table T-9 indicate that it would not be economically feasible to develop hydroelectric power at the Tusten site and no further consideration was given to the development of this site.

42. Hawks Nest Site. This site is located on Delaware River in Orange County, New York, and Pike County, Pennsylvania, about 259.2 miles above the Delaware Capes. It was selected after consideration of the Sparrow Bush and Mongaup sites, as well as other sites in this reach of river. The additional contributing drainage area between the Tusten site and the Hawks Nest site, including all of the Mongaup River drainage basin, is 1,068 square miles. This site was considered as a run-of-river development in Plans A, B, C, E, and H, to utilize the regulated flow provided by long term storage at the Hawk Mountain site. This site would be developed by constructing a concrete weir surmounted by crest gates across the Delaware River. The main line of the Erie Railroad follows the river in this reach and limits the pool elevation of the Hawks Nest site to 508 feet. Average tailwater is estimated at elevation 450. Peaking power would not be produced at this site since it is located only about 4.5 miles above the Port Jervis-Matamoras highway bridge and such flows would be objectionable through the Port Jervis area. No suitable afterbay site was found in this reach to reregulate peaking flows. Tables T-8 and T-9 show the principal characteristics, as well as the costs and benefits, associated with this project. The results of the preliminary appraisal, shown in Table T-9, indicate that it would not be economically feasible to produce hydroelectric power at the Hawks Nest site and no further consideration was given toward its development.

43. Knights Eddy Site. This site is located on Delaware River in Sullivan County, New York, and Pike County, Pennsylvania, about 263.4 miles above the Delaware Capes. It was selected in Plan D, after consideration of the Mongaup and the Minisink sites, as the location for a high dam to provide a storage project on this portion of Delaware River. Development of this site would provide sufficient storage to eliminate the need for developing the Hawk Mountain site and several of the downstream sites. The power sites considered at Callicoon, Skinners Falls, and Tusten would be flooded by the reservoir and the Hawks Nest site would be developed only as an afterbay to permit peaking at the Knights Eddy site. The Erie Railroad follows the river throughout the length of the Knights Eddy reservoir, and a branch of this railroad extends along the Lackawaxen River in the reservoir area. Both of these railroads would have to be relocated at higher elevations along the Delaware and Lackawaxen valley walls since the topography of the general area is such that it would be impracticable to relocate them outside the river valleys. The excessive costs for railroad relocation result in the economic infeasibility of this site being developed at this time. The contributing drainage area to Knights Eddy Reservoir, consisting of that below the Pepacton Reservoir on the East Branch, Delaware River, and Cannonsville Reservoir on West Branch, Delaware River, is 2,011 square miles.

The site would be developed to provide a multiple-purpose reservoir for flood control, water supply and hydroelectric power. The reservoir would have a maximum pool at elevation 793 that would provide 100,000 acre-feet of inactive storage below elevation 602; 1,200,000 acre-feet of long term storage between elevations 602 and 773; and 270,000 acre-feet of short term storage between elevations 773 and 793. Hydroelectric power would be produced by use of the 1,200,000 acre-feet of long term storage. The contributing drainage area, augmented by minimum yields from Pepacton and Cannonsville Reservoirs, and by the 1,200,000 acre-feet of Knights Eddy storage, would provide a gross minimum yield of 3,000 cubic feet per second. Average tailwater below the dam was estimated at elevation 495. Gross maximum power head would be 278 feet and average power head would be 221 feet. Installed capacity would amount to 239,000 kilowatts capable of producing an annual average of 592 million kilowatt-hours of energy. The power plant, power facilities and afterbay, <u>exclusive</u> of any allocation of cost for the Knights Eddy dam and reservoir, are estimated to cost $60,539,000 and require annual charges of about $3,570,000. Annual power benefits including those produced at the Hawks Nest afterbay are estimated at $9,268,000. The net benefit, for power facilities alone, is $5,698,000. This indicates that it would be economically feasible to construct power facilities at the Knights Eddy site. However, additional explorations at this site indicate poor foundation conditions, and the excessive cost due to these conditions and for the relocation of the main line of the Erie Railroad make it economically infeasible to develop this site at this time. Although power could be justified as an addition to the Knights Eddy project constructed for other purposes, conditions are such that there would not be overall justification for this multiple-purpose project including power.

44. <u>Wallpack Bend Site</u>. This site is located on Delaware River in Sussex County, New Jersey, and Monroe County, Pennsylvania, about 226 miles above the Delaware Capes. The site was considered as an alternate site for the Tocks Island site in Plans D, F, and G. The Wallpack Bend site would be developed as a multiple purpose project by the construction of a gravity type concrete dam to provide storage for flood control, downstream water supply, and for power production. The pool level would be limited to about elevation 420 feet by developments along the Delaware River at Port Jervis, New York. Tables T-8 and T-9 show the principal characteristics, as well as the costs and benefits associated with this project. The alternate Tocks Island site would provide greater storage capacities for water supply, flood control and other purposes and, accordingly, was the site, in this reach of Delaware River, selected for detailed study.

45. <u>Tocks Island Site</u>. This site is located on Delaware River in Warren County, New Jersey, and Monroe County, Pennsylvania, about 217.4 miles above the Delaware Capes. It is about 8.6 miles downstream from the alternate Wallpack Bend site, and has about 92 square miles of additional drainage area with about 50 percent more storage capacity. The Tocks Island site would be developed by construction of an earth-fill dam to provide storage for flood control, water supply, and for power production. In the preliminary studies the pool level was assumed to be limited to about elevation 420 by developments of communities along the Delaware River. Average tailwater would be at elevation 300. It was assumed to be developed as a part of Plans A, B, C, E, and H to provide 300,000 acre-feet of flood control storage, between elevations 420 and 395; 315,000 acre-feet of storage for water supply and power, between elevations 395 and 334, and 20,000 acre-feet of inactive storage below elevation 334. The contributing drainage area above this site is 2,912 square miles, exclusive of the area above the three reservoirs that divert water for New York City water supply. Tables T-8 and T-9 show the principal characteristics of this site as well as the costs and benefits associated with it. Table T-9 indicates that hydroelectric power production at the Tocks Island site would be economically feasible and this site was selected for more detailed investigation.

46. <u>Belvidere Site</u>. This site is located on Delaware River in Warren County, New Jersey and Northampton County, Pennsylvania, about 198.6 miles above the Delaware Capes. The contributing drainage area between Tocks Island site and the Belvidere site is 538 square miles, and is composed principally of the Brodhead Creek basin. The site would be developed as a run-of-river power project, in Plans A, B, C, D, E, F, G, and H, after regulated flows would be provided by Tocks Island or Wallpack Bend storage releases. The tracks of the Delaware, Lackawanna and Western Railroad, and of the Pennsylvania Railroad, Belvidere Branch, extend along the Delaware River in the reservoir area. These tracks, and other improvements in this reach, limit the pool level of this site to a maximum elevation of 280 feet. The site would be developed by constructing a concrete weir surmounted by crest gates across the valley. Average tailwater would be at elevation 235. Gross maximum power head would be 45 feet and minimum head would be approximately zero during high floods when this dam would be almost completely submerged. Operation of this development as a peaking plant would require the construction of an afterbay to reregulate peaking releases to avoid adverse conditions downstream and at Easton, Pennsylvania, about 15 miles below the site. The Chestnut Hill site about 13 miles downstream offers the only suitable site for this afterbay. Tables T-8 and T-9 show the principal characteristics of this site as well as the costs and benefits associated with it. Table T-9 indicates that the production of hydroelectric power would not be economically feasible at the Belvidere site and no further consideration has been given to it for power production.

47. Chestnut Hill Site. This site is located on Delaware River in Warren County, New Jersey, and Northampton County, Pennsylvania, about 185.9 miles above the Delaware Capes. The local contributing area between the Belvidere site and the Chestnut Hill site is 275 square miles. This site would be developed as a run-of-river power project in Plans A, B, C, D, E, F, G, and H after regulated flows would be provided by storage releases at the Tocks Island, or Wallpack Bend sites. The Pennsylvania Railroad, Belvidere Branch, follows the river throughout the reservoir area and limits the maximum pool level to elevation 200. The site would be developed by constructing a concrete weir surmounted by crest gates across the valley. Average tailwater would be at elevation 157. Gross maximum power head would be 43 feet and minimum head would be approximately zero during high floods when this dam would be almost completely submerged. Easton, Pennsylvania, is located about two miles downstream, and no suitable site was found for construction of an afterbay in this reach of the river to reregulate peaking power releases from the Chestnut Hill project. Therefore, it would not be feasible to operate a power plant at Chestnut Hill for peaking power. Tables T-8 and T-9 show the principal characteristics of this site, as well as the costs and benefits associated with it. Table T-9 indicates that it would not be economically feasible to produce hydroelectric power at the Chestnut Hill site and no further consideration has been given to its development.

48. Holland Site. This site is located on Delaware River in Hunterdon County, New Jersey and Bucks County, Pennsylvania, about 170.9 miles above the Delaware Capes. It was selected after consideration of the Riegelsville site and other potential sites in this reach of the Delaware River. It is located about 12.4 miles below the junction of the Lehigh River with the Delaware and has a contributing drainage area below the Chestnut Hill site of 1,717 square miles, a large portion of which is in the Lehigh River basin. This site was considered as a run-of-river development in Plans A, B, C, D, E, F, G, and H, to be constructed only after regulated flows would be provided by storage releases from Tocks Island, or Wallpack Bend, reservoirs. The Pennsylvania Railroad, Belvidere Branch, follows the river through the Holland reservoir and, together with existing developments at Riegelsville, New Jersey, limits the maximum pool at the Holland site to elevation 140. The site would be developed by constructing a concrete weir surmounted by crest gates across the valley. Average tailwater would be at elevation 100, providing a maximum gross head of 40 feet. Minimum gross head would be approximately zero during major floods, when this dam would be almost completely submerged. The location of Easton, Pennsylvania, immediately upstream from this reservoir, requires that Tocks Island peaking releases be reregulated before reaching this site, and therefore, such releases cannot be used for peaking at this site. Consideration was given to peaking with pondage from the Holland pool, but estimates showed that the additional power values from this type of peaking operation would not justify the additional costs. Tables T-8

and T-9 show the principal characteristics of this site as well as the costs and benefits associated with it. Table T-9 indicates that it would not be economically feasible to produce hydroelectric power at the Holland site and no further consideration was given to this site.

49. Eagle Island Site. This site is located on Delaware River in Hunterdon County, New Jersey, and Bucks County, Pennsylvania, about 153.8 miles above the Delaware Capes and about 5 miles above New Hope, Pennsylvania. It was selected after consideration of the Lumberville site and other potential sites in this portion of the Delaware River. It has a contributing drainage area below the Holland site of 270 square miles. This site was considered as a run-of-river power development in Plans A, B, C, D, E, F, G, and H, to be constructed only after regulated flows would be provided by the Tocks Island, or the Wallpack Bend, Reservoir storage. The Pennsylvania Railroad, Belvidere Branch, follows the river throughout the Eagle Island Reservoir, and together with existing development at several small towns along the river, limits the height of maximum pool to elevation 85. The site would be developed by constructing a concrete weir surmounted by crest gates across the valley. Average tailwater would be at elevation 60 providing a gross maximum head of 25 feet. The minimum gross head would be approximately zero during major floods when the dam would be almost completely submerged. Tables T-8 and T-9 show the principal characteristics of this site as well as the costs and benefits associated with it. Table T-9 indicates it would not be economically feasible to produce hydroelectric power at the Eagle Island site and no further consideration was given to it.

50. Goat Hill Site. This site is located on Delaware River in Hunterdon County, New Jersey and Bucks County, Pennsylvania. It is about 147.3 miles above the Delaware Capes and about 14 miles above Trenton, New Jersey. It was selected after consideration of several sites in this vicinity, including those at Yardley and Lumberville. The contributing drainage area below the Eagle Island site is 65 square miles. The Pennsylvania Railroad, Belvidere Branch, follows the river throughout the reservoir area, and together with developments at New Hope, Pennsylvania, and Lambertville, New Jersey, limits the maximum pool at this site to elevation 60. This site was considered as a run-of-river power development in Plans A, B, C, D, E, F, G, and H. It would be constructed only after regulated flows would be provided by releases from Tocks Island or Wallpack Bend Reservoirs. This site would be developed by constructing a concrete weir surmounted by crest gates across the river. Average tailwater elevation at this site would be at elevation 42 feet, providing a gross head of 18 feet for power production. Minimum head at this site would be approximately zero when major floods almost completely submerge this project. This site is only about 14 miles above Trenton, and a suitable site for a reregulating afterbay was not found in this reach. Therefore, it would not be feasible to install and operate a peaking power plant at this site.

Tables T-8 and T-9 show the principal characteristics of this site as well as the costs and benefits associated with it. Table T-9 indicates that it would not be economically feasible to produce hydroelectric power at the Goat Hill site and no further consideration was given to this site.

51. Lackawaxen Site. This site is located on Lackawaxen River in Pike County, Pennsylvania, about 3.2 miles above the junction of this river with Delaware River. The contributing drainage area above this site is 595 square miles, including 228 square miles above Wallenpaupack Dam, that contributes water to that reservoir for hydroelectric power production. This site was considered in Plan F as a storage development for flood control, water supply, and power. The site would be developed by constructing an earth fill dam across the Lackawaxen valley to provide a maximum reservoir pool to elevation 862. This would provide 80,000 acre-feet of flood control storage between elevations 808 and 862; 60,000 acre-feet of water supply and power storage between elevations 708 and 808; and 3,000 acre-feet of inactive storage below elevation 708. Average tailwater would be at elevation 620. Gross maximum head for power would be 178 feet and average power head would be 145 feet. The contributing drainage area would produce a gross maximum yield of 240 cubic feet per second. A branch line of the Erie Railroad follows the Lackawaxen River throughout the length of this reservoir, and a major highway extends along the river throughout a major portion of the reservoir's length. The cost of relocating these facilities would be very high, due to the rugged terrain. The installed capacity would amount to 12,500 kilowatts, capable of producing an annual average of 71.4 million kilowatt-hours of energy. The power plant and power facilities, exclusive of any cost for the dam and reservoir, are estimated to cost $5,649,000 and require annual charges of $372,000. Annual power benefits are estimated at $581,000. The net benefit for power facilities alone is $209,000. This indicates that it would be economically feasible to construct hydroelectric power facilities at the Lackawaxen site. However, the excessive cost of the dam and reservoir at the Lackawaxen site makes it economically infeasible to construct this development as a multiple purpose project at this time. Although power could be justified as an addition to the Lackawaxen project constructed for other purposes, conditions are such that there would not be overall justification for a multiple purpose project including power.

52. Shohola Falls Site. This site is located on Shohola Creek in Pike County, Pennsylvania. A storage reservoir would be created by the construction of a dam across the outlet of a marsh immediately above Shohola Falls, and about 9.1 miles above the junction of Shohola Creek with Delaware River. The drainage area above this site is 57 square miles. The project would be developed in Plans D and G by constructing a concrete-lined conveyance tunnel from the reservoir to a surge tank located on top of the cliffs along Delaware River, about 0.7 miles west of Parkers Glen, Pennsylvania. Steel penstocks would extend from this

surge tank to a powerplant located along the Delaware River, at about mile 270 above the Delaware Capes and opposite the village of Handsome Eddy, New York. The reservoir would have a maximum pool elevation of 1,181 feet. Flood control storage of 20,000 acre-feet would be provided between elevations 1,181 and 1,166, and water supply and power storage of 18,000 acre-feet between elevations 1,166 and 1,145. Inactive storage would be 2,000 acre-feet below elevation 1,145. Average tailwater in the Delaware River at the powerplant would be at elevation 550. Gross maximum power head would be 586 feet and average power head would be 579 feet. Tables T-8 and T-9 show the principal characteristics of this site as well as the costs and benefits associated with it. Table T-9 indicates that it would not be economically feasible to produce hydroelectric power at the Shohola Falls site by conventional type of development, and no further consideration was given to this type of development at this site.

53. Basher Kill Site. This site is located on Neversink River in Orange County, New York, about four miles above the junction of this river with the Delaware River at Port Jervis, New York. The site is about five miles below the Godeffroy site on this river and forms an alternate development for it. The Cejwin dam site was selected for this development after consideration of several alternate sites in the lower Neversink River valley. The reservoir provided by this dam would extend up the Neversink valley a short distance above the junction of Basher Kill at Roses Point and up the Basher Kill to the divide between the Delaware and the Hudson River watersheds. A maximum reservoir pool level to elevation 562 would permit water to flow across this divide. Several plans were investigated for development of structures in the vicinity of this divide to prevent this flow from the Basher Kill Reservoir. A site for this barrier across Basher Kill valley was selected just south of Wurtzboro, New York. The contributing drainage area to the Basher Kill reservoir would be 233 square miles, exclusive of 93 square miles above the Neversink Reservoir, that provides water for diversion to New York City's water supply. The site would be developed exclusively for hydroelectric power under Plans E, F, and G, by constructing earth fill type dams at the Cejwin and the Wurtzboro sites and a powerplant below the Cejwin site. The reservoir would provide 640,000 acre-feet of storage for power production in Plan E and 600,000 acre-feet in Plans F and G. The contributing drainage area would be too small to fill this reservoir, and diversion or pumping from the Delaware River would be required to provide the additional water needed for power production. Several schemes were investigated and pumping at the Cejwin site appeared to be the most economical. Reversible units would be installed to provide the pumped storage needed. Operation of these units would require the construction of an enlarged channel in the Neversink River from the site to the Delaware River at Port Jervis, New York, a distance of about four miles. It would also require the construction of a low impounding weir across the Delaware River about three miles below Port Jervis. This would be a concrete

weir surmounted by crest gates and would also provide an afterbay to reregulate peaking flows from the Basher Kill power plant. Tables T-8 and T-9 show the principal characteristics of the Basher Kill site as well as the costs and benefits associated with it. Table T-9 indicates it would not be economically feasible to produce hydroelectric power at the Basher Kill site under this scheme of development.

54. Tobyhanna Site. This site is located on Lehigh River in Carbon and Luzerne Counties, Pennsylvania, and 81.4 miles above the junction of this river with Delaware River at Easton, Pennsylvania. The contributing drainage area above this site is 224 square miles. Development of this site would consist of the construction of an earthfill type dam at the Tobyhanna site, a tunnel to a pond on the upper portion of Stony Creek, and penstocks to a powerplant located along the Beltzville Reservoir on Pohopoco Creek. The maximum pool in Tobyhanna Reservoir would be at elevation 1,530, for Plans A, B, D, E and H, and at elevation 1,550 for Plan F. Storage for water supply and power use would be 85,000 acre-feet for Plans A, B, D, E and H, and 140,000 acre-feet for Plan F. The average tailwater elevation in the Beltzville Reservoir at the powerplant would be at elevation 500. Tables T-8 and T-9 show the principal characteristics of this site, as well as the costs and benefits associated with it. Table T-9 indicates it would not be economically feasible to produce hydroelectric power at the Tobyhanna site and no further consideration was given to development of a conventional type plant for this site.

55. Preliminary Appraisal of Plan K. Plan K was proposed by the staff of the Federal Power Commission in New York City as a plan to be considered, primarily for development of the power potential of the Delaware River basin. The power projects included in plan K consisted of both conventional and pumped storage types of development, and were generally modifications of the conventional projects considered in the other plans discussed above. Under this plan, power would be developed at the following sites:

Shohola Falls	-	Shohola Creek
Basher Kill	-	Neversink River
Flat Brook	-	Flat Brook
Tobyhanna-Beltzville	-	Lehigh River
Tocks Island	-	Delaware River
Belvidere	-	Delaware River
Chestnut Hill	-	Delaware River

56. The first four of these were investigated as combined type pumped storage sites and the last three as conventional type developments whose yields would be increased by operation of the storage at the other sites. Storage for water supply and for flood control

would be provided under Plan K in all but the Belvidere and the Chestnut Hill sites. Therefore, a comparison of the benefits and costs of hydroelectric power, at all but these last two sites, was made on the basis of the cost of power facilities, exclusive of any costs for dams and reservoirs. Belvidere and Chestnut Hill sites were considered on the basis that power would have to pay the entire cost of these two developments.

57. Tables T-10 and T-11 show the principal characteristics of the conventional power sites in Plan K, as well as the costs and benefits associated with each of these sites. Table T-11 indicates that it would be economically feasible to produce hydroelectric power at the Tocks Island site. The pumped storage sites in Plan K were analyzed by a power work group. A discussion of this investigation is contained in subsequent paragraphs.

58. Pumped Storage Sites. The designation "pumped storage" is applied to a hydroelectric unit, plant, or system when all or part of the water used for hydroelectric power generation must be pumped into an upper reservoir before it becomes available for energy production. A "pure pumped storage" development is one in which all, or nearly all, of the available water is recirculated between an upper and a lower reservoir. The water may be pumped on a daily or weekly cycle during periods of light load and used for generation during periods of heavy load. A "combined pumped storage" development is one in which conventional storage is augmented by pumped storage during periods of light loads so as to provide additional generation during periods of heavy loads. As in "pure pumped storage" developments, the water may be pumped on a daily, weekly, or even seasonal basis, if sufficient storage can be provided. This second type provides even greater flexibility between pumping and generating cycles than the pure pumped storage plant. Both types of pumped storage developments were considered in making this appraisal.

59. Method of investigation. The District Engineer requested that a representative of the Federal Power Commission, acting as chairman, form a power work group to perform the necessary investigations and appraisals of pumped storage potentials in the basin and submit a report thereon. This mission required that the work group examine potential projects into which pumped storage might be incorporated and recommend the type of development to be used; estimate the cost and benefits from power production; and determine the feasibility of each of the projects investigated. The Power Work Group was composed of the following members from the organizations indicated:

Mr. John H. Spellman, Federal Power Commission, Chairman
Mr. Kenneth W. Ross, Federal Power Commission

TABLE T-10
DELAWARE RIVER SURVEY
PRELIMINARY APPRAISAL OF CONVENTIONAL POWER SITES
PROJECT DATA - PLAN K

Project:	Tocks Island	Belvidere	Chestnut Hill
Type of Development:	Storage	Run-of-River	Run-of-River
Location, stream	Delaware R.	Delaware R.	Delaware R.
Location, miles above mouth or Delaware Capes	217.4	198.6	185.9
Net drainage area, sq. mi.	2,912	3,450	3,725
Reservoir elev.			
Max. flood control	420	-	-
Max. power pool	395	305	206
Min. power pool	350	-	-
Storage capacity, acre-ft.:			
Flood control	300,000	-	-
Power	275,000	0	0
Total (b)	635,000	86,000	16,600
Average tailwater elev.	300	235	157
Net head, max.	95	70	49
, min.	50	70	(a)
, average	80	70	49
Regulated flow, c.f.s.			
Critical period	2,785	2,875	2,920
Average for power	5,700	6,650	6,825
Power			
Installed capacity, kw.	80,300	72,500	26,500
Dependable capacity, kw.(c)	80,300	72,500	10,300
Average annual energy, kw.-hr.	284.1	290.0	208.3
Load factor in critical period	20	20	100

(a) Approximately zero during high floods due to submergence.
(b) Includes flood control, power and inactive storage.
(c) For preliminary estimates, dependable capacity was computed using water available and average head during critical period.

TABLE T-11
DELAWARE RIVER SURVEY
PRELIMINARY APPRAISAL OF CONVENTIONAL POWER SITES
ECONOMIC DATA - PLAN K

Project:	Tocks Island	Belvidere	Chestnut Hill
Construction cost	$33,200,000(a)	$72,440,000(b)	$28,267,000(b)
Interest during construction	1,660,000	3,622,000	1,413,000
Investment	$34,860,000	$76,062,000	$29,680,000
Average Annual charges (c)			
Interest, amortization, major replacements,	$1,743,000	$3,402,000	$1,283,000
Operation and maintenance	226,000	294,000	185,000
Total	$1,969,000(a)	3,696,000(b)	$1,468,000(b)
Average Annual benefits			
Dep. capacity at $27.55/kw.	$2,212,000	$1,997,000	$284,000
Energy at 3.32 mills/kw.-hr.	943,000	963,000	692,000
Total	$3,155,000	$2,960,000	$976,000
Average Annual Net Benefit	$1,186,000	-736,000	-492,000

(a) Power facilities only (i.e. dam and reservoir excluded).
(b) Entire project including dam, reservoir, and powerhouse.
(c) Interest, amortization, and interim replacement charges were taken as 5 percent for power facilities. Interest and amortization charges were taken as 4 percent for dams and reservoirs. O & M charges are from plates T-4 and T-5.

Mr. Lazar B. Woll, Federal Power Commission
Mr. David E. Donley, U. S. Army Engineer District, Philadelphia
Mr. Charles A. Carpenter, Pennsylvania Power & Light Co.
Mr. Morris D. Hooven, Public Service Electric & Gas Co.
Mr. Edward S. Loane, General Public Utilities Corp.
Mr. Richard A. Lane, Philadelphia Electric Company
Mr. Edward W. Bartley, New York State Electric & Gas Corp.
Mr. L. Earle Merrow, Orange & Rockland Utilities Co.

The group considered development of hydroelectric power by means of pumped storage at five of the sites previously listed in Plan K and at a sixth pumped storage project proposed by the New Jersey Power & Light Company. An appraisal of pumped storage potential was made at the following six sites:

Tobyhanna-Beltzville	- Lehigh River
Basher Kill	- Neversink River
Shohola Falls	- Shohola Creek
Flat Brook	- Flat Brook
Tocks Island	- Delaware River
Yards Creek	- Yards Creek

The group investigated these sites and prepared a report showing the methods used and the results obtained. This report is on file in the U. S. Army Engineer District, Philadelphia. Although all economic analyses shown for the pumped storage projects are on the basis of private financing, subsequent studies indicated that the feasibility or infeasibility of the projects were not dependent on the method of financing assumed. The sites studied by the Power Work Group are discussed in subsequent paragraphs.

60. Tobyhanna and Beltzville Sites. These sites are located on Lehigh River and Pohopoco Creek, respectively, in Carbon County, Pennsylvania. The Beltzville site was considered for development as a pure pumped storage installation with an upper reservoir provided on the headwaters of Stony Creek and the Beltzville reservoir forming the lower reservoir. The Stony Creek-Beltzville project was also considered as a part of a larger combined pumped storage development that would use water stored at the Tobyhanna site on Lehigh River and conveyed to the upper reservoir on Stony Creek. The Beltzville site is located about 0.6 miles northeast of Beltzville, Pennsylvania, and has a contributing drainage area of about 75 square miles, exclusive of 22 square miles above the Wild Creek Dam, which diverts water to the City of Bethlehem, Pa. It would be developed by constructing an earth fill type dam across Pohopoco Creek to form a reservoir that would provide flood control and water supply, as well as water for pumping to the Stony Creek Pond for power production. The Beltzville site would provide 30,000 acre-feet of flood control storage, between elevations 603 and 635; 24,000 acre-feet of water supply storage between elevations 553 and 603; and 7,000 acre-feet of inactive storage below elevation 553.

A power and pumping plant would be constructed on the right side of the reservoir. The plant would pump water from the water supply storage and would discharge back into this storage during the power production cycle. Power operation of the combined development would discharge additional water from the Tobyhanna storage into the Beltzville reservoir. The power and pumping plant for this development would have three reversible type units, each with a rating of 134,000 horsepower and each direct-connected to a 100,000-kilowatt generator. For the pumping cycle a motor capacity of 350,000 kilowatts is required to pump water from Beltzville Reservoir in Stony Creek Pond. Tailwater at the plant would be controlled by operation of Beltzville Reservoir and would fluctuate between elevations 553 and 635.

61. Stony Creek Pond would be constructed to form the upper reservoir by building an earth fill type dam across Stony Creek near its headwaters. This dam would have a crest length of about 7,000 feet at elevation 1,560, and a maximum height of about 100 feet. It would provide about 20,000 acre-feet of storage for water supply and power use. Operation of the pure pumped storage project would require about 17,000 acre-feet to be pumped each week into the upper reservoir from the Beltzville reservoir. Operation of the combined project with water diverted from Tobyhanna storage would reduce the pumping requirement to about 12,800 acre-feet.

62. The Tobyhanna site would be developed by constructing an earth fill type dam across Lehigh River, about 0.8 miles below the mouth of Tobyhanna Creek and about 81 miles above the mouth of Lehigh River. The dam would provide a reservoir with 85,000 acre-feet of water supply and power storage, between elevations 1,542 and 1,490, and 27,000 acre-feet of inactive storage below elevation 1,490. Water would be conveyed from this reservoir to Stony Creek Pond through a 10-foot diameter tunnel about 9.7 miles long, with a capacity of 750 cubic feet per second. This would supply a yield of about 417 cubic feet per second for use in the combined pumped storage development. Water would be conveyed between Stony Creek Pond and the power and pumping station, through a tunnel about 4.1 miles long and 20 feet in diameter. The pumping cycle would require 71 hours per week for either type of pumped storage installation. The energy requirement for pumping is estimated at about 1,036 million kilowatt-hours annually of offpeak energy for the pure pumped storage installation, and about 749 million kilowatt-hours annually for the combined installation. The generating cycle for either installation would be 74 hours per week and would produce annually about 715 million kilowatt-hours of energy.

63. Table T-12 shows the cost estimate for the power facilities that would be required for each type of development.

TABLE T-12
ESTIMATED COST
TOBYHANNA-BELTZVILLE PUMPED STORAGE PROJECT

	Pure Pumped Storage Project	Combined Project
Tobyhanna-Stony Cr. Tunnel	-	$8,335,000
Stony Creek Pond	$4,800,000	4,800,000
Stony Creek - Power plant Tunnel	19,737,000	19,737,000
Power and Pumping Plant	18,020,000	18,020,000
Subtotal	42,557,000	50,892,000
Overhead @ 25%	10,639,000	12,735,000
Total cost of power facilities	53,196,000	63,627,000

The costs shown in the above table are equivalent to $177.00 per installed kilowatt for the pure pumped storage project and $212.00 per kilowatt for the combined project.

64. Annual charges estimated for the two types of installation are as follows:

	Pure Pumped Storage Project	Combined Project
Annual fixed charge	$5,559,000	$6,660,000
Annual fixed operating charges	300,000	375,000
Annual pumping energy	3,630,000	2,619,000
Transmission charges	636,000	636,000
Total	10,125,000	10,290,000

The alternative cost of producing the equivalent power by use of steam electric plants was estimated by the Power Work Group at $24.02 per installed kilowatt (including cost of fossil fuel), or $7,206,000 as the annual benefit to be realized from either type of pumped storage development. Comparison of annual benefits with annual charges shows that charges exceed the benefits for both the pure pumped storage project and for the combined project. The above comparisons indicate that it would not be economically feasible to develop hydroelectric power by pumped storage as a part of the Tobyhanna-Beltzville project at this time.

65. Basher Kill Project. The development of pumped storage to augment the natural flows available at Basher Kill site was considered by the Power Work Group. This reservoir would have a

useful storage capacity of 600,000 acre-feet between full pool at elevation 610 and minimum pool at elevation 545. Use of this storage for augmenting the flow of the Delaware River has been analyzed on the basis of a 27-year period. This study indicates that the reservoir would normally be drawn to elevation 595 each year and occasionally to elevation 580, except in the very low year of 1931. The average operating level would be at about elevation 595. The average tailwater level would be at elevation 415 and the average head would be 180 feet. The pondage required for pumping would be provided by a reregulating weir constructed across the Delaware River about three miles below Port Jervis. This pondage would permit the pumping of surplus flows from the Delaware River into the Basher Kill Reservoir and their use for power at this site.

66. The estimated cost of the power and pumping facilities (including a reregulation weir but excluding Cejwin dam and reservoir) is about $72,331,000. This cost would be equivalent to $301 per installed kilowatt for a 240,000 kilowatt installation. Table T-13 shows the economic analysis developed for this plant. This table indicates that the combined pumped storage project at Basher Kill is not economically feasible at this time.

67. <u>Shohola Falls Pumped Storage Project</u>. This combined pumped storage project would consist of the same dam and reservoir designed for the conventional development at this site. In addition, a pumping plant with a capacity of 2,000 horsepower would be constructed just below the Shohola Falls dam. A pipeline and tunnel would extend from the pumping plant to Walker Lake Creek and discharge into this creek above Walker Lake. An upper reservoir would be provided by constructing an earth fill type dam across Walker Lake Creek. A short tunnel would convey water between this upper reservoir and a surge tank located on the bluffs above the Delaware River opposite Parkers Glen, New York, and steel penstocks would extend from this surge tank to a power plant located on Delaware River opposite Parkers Glen. An afterbay would be provided by constructing a weir across Delaware River at about mile 268.8, or about 2.3 miles above the Pond Eddy, New York, highway bridge across the river. This afterbay would serve as a reregulating pond and as the lower reservoir for pumping Delaware River water back into the Walker Creek Pond. The installation at Parkers Glen power plant would consist of two conventional type units and one reversible type unit. Each of these would have a capacity of 20,100 horsepower, when operating as turbines, and be direct-connected to 15,000-kilowatt generators. It is estimated that the average annual output of this plant would be about 82 million kilowatt-hours of energy.

68. The preliminary cost estimate for the combined pumped storage development of Shohola Falls is $16,311,000 for the power facilities only. An economic comparison, prepared on the same basis as that used for the Tobyhanna-Beltzville project, is shown in table T-14. This table shows that the net annual costs for the pumped storage installation at Shohola Falls exceed the costs for alternative steam. This project is, therefore, not economically feasible at this time.

TABLE T-13
COMPARISON OF COST AND BENEFIT
BASHER KILL COMBINED PROJECT

	Basher Kill Hydro Plant	Alternate Steam Plant
Installed Capacity (net kw.)	240,000	350,000
Annual Output (mil kw.-hr.) 1/		
From natural flow	64	-
From pumping	462	-
From fuel	-	1,575
Total	526	1,575
Annual Pumping Energy (mil kw.-hr.)	660	-
Installed cost - $/kw.		
Plant	301	200
Transmission 2/	80	10
Total	381	210
Annual Capacity Cost - Plant $/kw.		
Fixed charges 3/	36.94	27.60
Fixed operating costs	1.80	3.00
Total	38.74	30.60
Annual Energy Cost - Plant $/kw.		
As operated 4/	12.20	16.20
Credit for excess steam generation 5/	-	11.50
Net total	12.20	4.70
Annual Capacity Cost - Trans. $/kw.		
Fixed charges 6/	10.40	1.25
Fixed operating costs	0.40	0.05
Total	10.80	1.30
Total net annual cost - $/kw.	61.74	36.60

1/ Capacity factors assumed - Hydro 25%, Steam 51.4%.
2/ Includes plant step-up substation.
3/ Assumed hydro 11.8%, 4% losses; steam 13.8%.
4/ Hydro pumping energy assumed at 4.00 mills per kw.-hr., with 6% losses.
5/ Value assumed at 5.0 mills per kw.-hr.
6/ Assume hydro at 12.5% with 4% losses; steam at 12.5%.

TABLE T-14
COSTS AND BENEFITS - SHOHOLA FALLS
COMBINED PUMPED STORAGE PROJECT

		Combined Project		Alternative Steam
Installed Capacity kw.		45,000		50,000
Annual Output - million kilowatt-hours				
From natural flow		55		-
From pumping		27		-
From fuel		-		235
Total		82		235
Annual Pumping Energy million kw.-hr.		39		-
Installed cost - Million Dollars				
Plant		16.3		7.5
Transmission		0.9		0.5
Total		17.2		8.0
Annual Capacity Cost - Million Dollars				
Fixed charges	@ 10.47%	1.80	@11.33	0.85
Fixed operating costs		0.06		0.10
Total		1.86		0.95
Annual Energy Costs - Million Dollars				
Hydro pumping energy 39 mil. kw-hr.	@ 3.50 mills	0.14		
Steam energy 235 mil. kw-hr.	@ 3.25 mills	-		0.76
Credit for excess generation	@ 4.25 mills	-		0.65
Net Total		0.14		0.11
Annual Capacity Cost Trans. - Million Dollars				
Fixed charges 10.27%		0.09		0.05
Fixed operating costs		0.01		0.01
		0.10		0.06
Net annual costs - Million Dollars		2.10		1.12

69. Flat Brook Project. This site is located on Flat Brook in Warren County, New Jersey, about one mile above the mouth of this stream. The staff of the Federal Power Commission, New York City, made a preliminary study of the development of this site as part of a combined pumped storage project. This study was also considered by the Power Work Group. This project would be an adjunct to the Tocks Island project and that reservoir would constitute the lower reservoir from which water would be pumped. The site would be developed by constructing an earth fill type dam across Flat Brook, about one mile above the mouth of that stream, that would form a reservoir with a maximum pool at elevation 550, and a minimum pool at elevation 460. The reservoir would provide a usable storage of 280,000 acre-feet and would serve as the upper reservoir for the project. The contributing drainage area above this site is only 65 square miles and most of the reservoir storage would have to be filled by pumping Delaware River water from Tocks Island Reservoir. When both reservoirs were full, Flat Brook at elevation 550 and Tocks Island at elevation 405, the head would be 145 feet. When both reservoirs were drawn down to the top of inactive storage the head would be 126 feet. In normal years the reservoir levels would only be drawn to elevation 385 in Tocks Island Reservoir and about elevation 510 in Flat Brook, leaving a minimum gross head of 125 feet. A pumping capacity of 120,000 kilowatts would be required for filling the reservoir during off-peak power periods in winter months. This installation was increased to 180,000 kilowatts to provide ample generating capacity. Three reversible Francis type units, each with a capacity of 60,000 kilowatts, would be installed at this site. These would be installed in a power plant located just below the Flat Brook dam, and would discharge back into Tocks Island reservoir.

70. Preliminary estimates for the Flat Brook dam and reservoir indicate that these features would cost $35,225,000. The cost of the power and pumping plant for 180,000 kilowatts of installed capacity with a head of 125 feet was estimated at $39,800,000. The additional cost of waterways and auxiliary equipment would bring the total investment to $52,925,000. Table T-15 shows the cost and benefits of this project if analyzed on the same basis as that used for pumped storage at the Tocks Island site, and includes only the costs for the power facilities. This table shows the benefits based on the alternate cost of steam to be $4,988,000 per year while the cost of producing them by hydro-power would be $6,984,000 per year, which indicates that pumped storage is not economically feasible at the Flat Brook site at this time.

TABLE T-15
COST AND BENEFITS - FLAT BROOK
COMBINED PUMPED STORAGE PROJECT

	Combined Project	Alternative Steam
Installed Capacity - kw.	180,000	180,000
Installed Cost		
Plant	$52,925,000	$30,600,000
Transmission	(assume same for both)	
Annual capacity costs		
Fixed charges - 10% hydro 1/	5,292,000	-
10.5% steam 1/	-	3,210,000
Operation and maintenance	216,000	360,000
Administrative & general expense	72,000	90,000
Cost of fuel inventory	-	18,000
Allowance for greater unavailability of steam 5% of other cap. costs	-	180,000
Total capacity costs	$5,580,000	$3,858,000
Fuel costs (incl. incremental maintenance, steam, 4,500 hours at 3.5 mills	-	2,840,000
Pumping energy for 2,000 hours use of generation (3,000 kw.-hr/kw @ 2.6 mills	1,404,000	-
Additional steam generation for 2,500 hours @ 3.8 mills	1,710,000	-
Total energy costs for 4,500 hrs.	$3,114,000	$2,840,000
Deduct: Additional steam cost necessary to match hydro service (2,000 hrs) with steam (4,500 hours) at 3.8 mills)	1,710,000	1,710,000
Net cost of energy 2,000 hours	$1,404,000	$1,130,000
Total capacity and energy costs with 2,000 hours generation	$6,984,000	$4,988,000

1/ Does not include state and local taxes which are both revenue taxes in State of New Jersey.

71. Kittatinny Mountain Projects. The New Jersey Power & Light Company has been considering the development of pumped storage projects in the vicinity of the Tocks Island site for several years. A consulting firm has proposed preliminary designs and estimates as well as reports on two plans for pumped storage development in this area. The New Jersey Power & Light Company very generously made all of these data available for consideration by the Power Work Group, and prepared additional data for use by the Group. These investigations show that suitable sites for upper reservoirs are located on top of Kittatiny Mountain, near Sunfish Pond in Warren County, New Jersey, and almost directly south of the Tocks Island dam site. A site also exists for a lower reservoir on the upper portion of Yards Creek, a tributary of Paulins Kill. Water would be pumped westward from this reservoir into one of the upper reservoirs, from which it would be returned to the lower reservoir at Yards Creek to produce hydroelectric power. This potential development has been designated as "Kittatinny Mountain - Yards Creek Pumped Storage Project" and will be referred to hereafter as the "Yards Creek Project." The consulting firm investigated three schemes for pumping water from Delaware River, in the vicinity of Tocks Island site, to upper reservoirs on Kittatinny Mountain. These potential developments have been designated as "Kittatinny Mountain - Delaware River Pumped Storage Project," but will be referred to hereafter as the "Tocks Island Project" since they are so closely related to the potential conventional development of that site. The Power Work Group also considered the possibility of combining the Yards Creek and the Tocks Island projects for future joint operation. The locations and general features of these projects are shown on plates T-6 and T-7.

72. Yards Creek Project. The New Jersey Power & Light Company began an investigation of a pumped storage project in the Paulins Kill basin in Warren County, New Jersey, in 1956. The project would consist of a lower reservoir formed by a dam across Yards Creek near its headwaters, and an upper reservoir constructed on the top of Kittatinny Mountain, about a half mile east of Sunfish Pond and almost one mile directly south of the Tocks Island dam site. A power plant would be constructed a short distance upstream from the dam on Yards Creek and would be connected to the upper reservoir by penstocks and a canal about 5,750 feet long. The lower reservoir would have a usable storage capacity of 2,660 acre-feet and a total capacity of 4,600 acre-feet. The upper reservoir would have a usable capacity of 2,660 acre-feet and a total capacity of 3,300 acre-feet. The power installation would consist of two reversible generating and pumping units of 75,000 kilowatts capacity each, operating under an average head of approximately 700 feet. The units would each have a capacity of 103,000 horsepower, when operated as turbines, and would each require a motor capacity of 124,500 horsepower, for operation as pumps. The plant would be operated to produce power on an average of about 34 hours per week, or at about a 20 percent load factor. Pumping would

be done on the average of 42 hours per week at an average rate of 2,500 cubic feet per second, against an average dynamic head of 750 feet. Preliminary designs and cost estimates were prepared for this project in 1958 by a consulting engineer firm for the New Jersey Power & Light Company and were furnished for consideration by the Power Work Group. The location and general features of this project are shown on plate T-6. The cost estimates showed an estimated first cost for this project of $25,140,000, or $167.60 per kilowatt of installed capacity. This included the cost of a plant substation but no costs for any transmission facilities. Table T-16 shows a summary of the estimated cost for this project as determined by the consulting engineer firm.

TABLE T-16
SUMMARY OF COST ESTIMATE -
YARDS CREEK PUMPED STORAGE PROJECT

Land and Land Rights	$350,000
Power plant Structures	825,000
Reservoirs, Dams and Waterways	
Upper Reservoir and Dams	2,530,000
Lower Reservoir and Dams	647,000
Canal and Intake Structure	1,720,000
Penstock and Valves	3,595,000
Tailrace and Screen Structure	168,000
Pump-turbine & Motor/Generators	6,390,000
Accessory Electric Equipment	900,000
Miscellaneous Powerplant Equipment	410,000
Permanent Roads	525,000
Substation Structure and Equipment	715,000
Direct Construction Cost	$18,775,000
Indirect Construction Cost	985,000
Omissions and Contingencies	2,960,000
Specific Construction Cost	$22,720,000
Overhead and Undistributed Cost	1,150,000
Interest During Construction	1,270,000
Total Project Cost	$25,140,000

An approximate economic analysis has been made of this project based on data supplied in connection with the Kittatinny Mountain-Delaware River Pumped Storage Project. This analysis is shown in table T-17.

TABLE T-17
COSTS AND BENEFITS - YARDS CREEK
PUMPED STORAGE PROJECT

	Hydro Project	Alternative Steam
Installed capacity, kw.	150,000	150,000
Installed cost, - Plant	25,140,000	25,500,000
- Transmission	(Assume same for hydro & steam)	
Annual capacity costs		
Fixed charges - 10% hydro 1/	2,514,000	-
- 10.5% steam 1/	-	2,680,000
Operation and maintenance	180,000	300,000
Administrative and General Expense	60,000	75,000
Cost of Fuel Inventory	-	15,000
Allowance for Greater Unavailability of Steam, 5% of other capacity costs	-	150,000
Subtotal - Capacity Costs	$2,754,000	$3,220,000
Fuel Costs (Incl incremental maint.) Steam, 4,500 hours and 3.5 mills	-	2,363,000
Pumping energy for 2,000 hours use of generation (3,000 kw.-hr/kn at 2.6 mills)	1,170,000	-
Additional Steam Generation for 2,500 hours at 3.8 mills	1,425,000	
Subtotal - Energy Costs for 4,500 hours	$2,595,000	$2,363,000
Deduct: Additional steam cost necessary to match hydro service (2,000 hours) with steam (4,500 hrs.)	1,425,000	1,425,000
Net cost of energy for 2,000 hrs.	$1,170,000	$938,000
Total capacity and energy costs with 2,000 hours of generation	$3,924,000	$4,158,000

1/ Does not include state and local taxes (revenue taxes)

The above analysis indicates that the pumped storage projects at Yards Creek can supply peaking capacity and energy more cheaply than steam.

73. Tocks Island Pumped Storage Project. The New Jersey Power & Light Company, of Denville, New Jersey, has investigated a pure pumped storage project to be constructed at the Tocks Island site. This project would be developed by constructing an upper reservoir on the top of Kittatinny Mountain, above the dam site at Tocks Island, and developing a lower reservoir in Delaware River from which to pump in the vicinity of Tocks Island. Three schemes were considered for developing the plant and lower reservoir for this project. Scheme A is a plan for pumped storage which would not depend upon the existence of Tocks Island dam but would include the construction of a low weir located about 1,500 feet below the lower end of Tocks Island, with crest at about elevation 320, to provide the lower reservoir. The powerplant would be constructed above this weir and would pump from the pool provided by it to the upper reservoir on Kittatinny Mountain. Scheme B would utilize part of the storage provided in the Tocks Island reservoir and would pump from this reservoir to the same upper reservoir, as in Scheme A. The plant would be located below the Tocks Island dam and would be so designed as to discharge into the Tocks Island reservoir during the generating period of the cycle. Scheme C would be the same as Scheme B, except that the powerplant would discharge into Delaware River below the Tocks Island dam. The locations and general features of these schemes are shown on plate T-7.(Subsequent investigations at Tocks Island changed the location of the spillway from right to left bank as shown on plate T-8.) Schemes B and C would permit the construction of a conventional powerplant at the Tocks Island site for operation in addition to the pumped storage development. Table T-18 shows comparative data for the three schemes as prepared by a firm of consulting engineers for the New Jersey Power & Light Company.

TABLE T-18
PHYSICAL CHARACTERISTICS -
TOCKS ISLAND PUMPED STORAGE PROJECT

	Scheme A	Scheme B	Scheme C
Upper Level Reservoir			
Max. Water Level - elev. ft.	1545	1545	1545
Minimum Water Level - elev. ft.	1480	1480	1480
Max. Reservoir Area - acres	165	165	165
Usable Storage - acre-ft.	7500	7500	7500
Lower Level Reservoir			
Max. (for power only) Water Level - elev. ft.	320	395	395
Min. Water Level - elev. ft.	307	360 1/	360 1/
Max. Reservoir Area - acres	900	Tocks Island pool	
Usable Storage - acre-ft.	7500	Tocks Island pool	
Generation			
Average Net Head - ft.	1165	1100	1182
Discharge at Aver. Head - cfs	4600	4600	4600
Capacity at Aver. Head - mw	386	366	396
Generating Time per Week - hrs	42	42	42
Pumping			
Aver. Dynamic Head - ft.	1242	1177	1177
Discharge at Aver. Head - cfs	3240	3240	3240
Required Motor Input - mw	400	376	376
Pumping Time per Week - hrs.	60	60	60

1/ Tocks Island minimum pool elevation assumed to be elevation 360 by the consulting engineers.

Comparative cost estimates for the three schemes were prepared by the firm of consulting engineers for the New Jersey Power & Light Company, at the request of the Power Work Group. These comparative costs are shown in table T-19.

TABLE T-19
COMPARATIVE COSTS - TOCKS ISLAND
PUMPED STORAGE PROJECT

	Scheme A	Scheme B	Scheme C
Land and Land Rights	Not Incl.	Not Incl.	Not Incl.
Powerplant and Structures	$1,285,000	$1,195,000	$1,315,000
Reservoir, Dams, and Waterways			
Upper Reservoir Dikes	6,120,000	6,120,000	6,120,000
Delaware River Overflow Dam	2,755,000	-	-
Delaware River Reregulating Dam	-	-	1,695,000
Waterways	11,500,000	12,430,000	13,820,000
Pump-turbine and Generator-Motor	10,820,000	10,475,000	11,020,000
Accessory Electric Equipment	1,000,000	1,000,000	1,000,000
Miscellaneous Powerplant Equipment	580,000	580,000	580,000
Permanent Roads	650,000	650,000	650,000
Substation Structure and Equipment	3,250,000	3,250,000	3,250,000
Direct Construction Cost	$37,960,000	$35,700,000	$39,450,000
Indirect Construction Cost	1,900,000	1,800,000	2,000,000
Omissions and Contingencies	7,940,000	7,500,000	8,290,000
Specific Construction Costs	47,800,000	45,000,000	49,740,000
Overhead and Undistributed Costs	1,700,000	1,600,000	1,760,000
Interest during construction	4,500,000	4,200,000	4,600,000
Total Project Cost (less Land)	$54,000,000	$50,800,000	$56,100,000
Unit cost per kw. cap.	$139.90	$138.80	141.65

74. The relative costs of the three schemes in total dollars are indicated in the above table, Scheme A costs more than Scheme B, and Scheme C costs more than Scheme A. It must be remembered, however, that the differences between these estimates are subject to a higher order of uncertainty that the estimates themselves. Consideration of the variation in plant capacity available, as between the three plans, brings them very nearly to the same unit costs in terms of dollars per installed kilowatt. Comparison among the several plans, however, must take into consideration certain costs which have been omitted in the above comparative estimates. The omitted costs are significantly different in the several plans. All the schemes omit the cost of the upper reservoir

area, but this is small and is common to each. The differences occur with respect to the lower reservoir and related lands or structures. Scheme A omits the cost of lands and rights-of-way necessary for construction of a dam in Delaware River, below the Tocks Island site, with a crest at elevation 320. These lands and rights-of-way would add significantly to the cost of Scheme A. In Scheme B, the lower reservoir would be provided by construction of Tocks Island dam for water supply and other purposes and land costs are included in the reservoir cost. Payment for the use of Tocks Island storage was, however, omitted from the costs applicable to Scheme B. A similar omission of the cost for the required Tocks Island storage was made in Scheme C. These estimates were made by the utility company for use of the Power Work Group to measure the advantage of including pumped storage development in the overall development of the Tocks Island Project.

75. Comparison of Schemes B and C involves recognition of only the following facts that are peculiar to Scheme C since the same omissions were made from both schemes:

(1) Scheme C provides for discharge below the Tocks Island dam and this peak discharge requires reregulation. The estimated cost of a reregulating dam at the Delaware Water Gap to control peak flows has been shown in the above analysis for Scheme C as entirely applicable to the pumped storage plant.

(2) In any case, no provision has been made in the above estimates for land and flowage rights needed for the construction of the reregulating structure. The inclusion of such costs may add significantly to the cost of Scheme C.

(3) The 30,000-kilowatt higher capacity of Scheme C, as compared to Scheme B, is not a net gain in capacity of the projects related to Tocks Island. A substantial part of this gain would be offset by a reduction in the dependable capacity of the conventional plant. Similarly, any gain in energy production of the pumped-storage plant in Scheme C, as compared to Scheme B, would be almost offset by the reduction in energy that could be produced by the conventional plant.

(4) Possibly the conventional plant could be made samller (in view of the reduced water available with Scheme C), and the savings in costs and differences in its output would then enter into an economic justification of Scheme C.

Based on present information, it appears that Scheme C is less favorable than Scheme B, but this question will require re-examination when a definite project design is undertaken.

76. A preliminary economic analysis has been made of the Tocks Island pumped storage project based on data supplied the Power Work Group by the New Jersey Power & Light Company. This economic study follows, insofar as practicable, the procedure outlined for such studies in Federal Power Commission Memorandum No. 1. Pumped storage costs were assumed by New Jersey Power & Light Company to be either $140, or $150 per kilowatt installed, the lower figure being without payment for Tocks Island Reservoir storage and the upper assumed to be more than enough to cover any reasonable charge for such storage. Alternative steam capacity was assumed to be installed in a nearby site at Portland, Pennsylvania, in units with a gross capability of 250,000 kilowatts. The costs of this steam capacity was estimated by the New Jersey Power & Light Company at $170 per kilowatt of installed capacity, based on data in the files of that company. The cost of transmission was omitted from the comparison since it would be approximately the same for either hydro or steam power at this site. Table T-20 shows the results of this economic analysis for the pumped storage project at Tocks Island under these basic assumptions.

TABLE T-20
COMPARISON OF COSTS AND BENEFITS
TOCKS ISLAND PUMPED STORAGE PROJECT

(All values in dollars per net kilowatt installed)

	Pumped Storage		Alternate Steam
Installed cost - plant	$140	$150	$170
Installed cost - Transmission	Assumed the same for both hydro and steam.		
Annual Capacity costs			
Fixed charges - 10% hydro 1/	14.00	15.0	-
Fixed charges - 10.5% steam 1/	-	-	17.85
Operation and Maintenance	1.20	1.20	2.00
Administrative & General Expense	0.40	0.40	0.50
Cost of Fuel Inventory	-	-	0.10
Allowance for greater unavailability of steam, 5% of other capacity costs	-	-	1.00
Subtotal - capacity costs	$15.60	$16.60	$21.45
Fuel costs (incl. incremental maint.) steam, 4500 hours @ 3.5 mills	-	-	15.75
Pumping energy for 2000 hours, use of generation (3000 kw. - hr. @ 2.6 mills	7.80	7.80	-
Additional steam generation for 2500 hours @ 3.8 mills	9.50	9.50	-
Subtotal - Energy costs for 4500 hours	$17.30	$17.30	$15.75
Deduct: Additional steam cost necessary to match hydro service (2000 hrs.) with steam (4500 hrs)	(9.50)	(9.50)	(9.50)
Net cost of energy for 2000 hrs.	$7.80	$7.80	$6.25
Total capacity and energy costs with 2000 hours of generation	$23.40	$24.40	$27.70

1/ Does not include state and local taxes which are both revenue taxes in the State of New Jersey.

77. Comparison of the costs in Table T-20 with benefits assumed equal to alternative value of steam shown in the same table indicates a net benefit of $4.30 per net kilowatt installed if the cost of pumped storage power at the Tocks Island project is $140 per kilowatt installed, or a net benefit of $3.30 per net kilowatt installed if the cost is $150 per kilowatt installed.

78. The data supplied the Power Work Group also considered the possible use of an additional reservoir in the vicinity of Sunfish Pond on Kittatinny Mountain for supplemental storage at a lower elevation. Useful storage of about 3,750 acre-feet could be obtained in this reservoir at about 100 feet lower elevation than in the other upper reservoirs considered for the Tocks Island and the Yards Creek projects. Using this storage capacity, and allowing for a difference in head of about 100 feet, an additional capacity of about 165,000 kilowatts could be developed on a basis comparable to Scheme B and about 180,000 kilowatts on a basis comparable to Scheme C. (This capacity is in addition to the capacity shown in Table T-18 for Schemes B and C.) A range of 150,000 kilowatts to 200,000 kilowatts, appears not unreasonable as an estimate of the additional capacity that might be gained by use of this additional upper reservoir storage. No costs have been determined for this additional capacity but it is believed that they would be approximately the same as those for the Tocks Island pumped storage project, or about $140 per installed kilowatt.

79. Additional Water Supply for New Jersey

Data furnished the Power Work Group also cover the combined use of the Tocks Island and the Yards Creek pumped storage projects to provide 150 million gallons of water per day for diversion from Delaware River for use in northeastern New Jersey. This would be accomplished by arranging the power and pumping plants, waterways, and reservoirs of the two projects so as to provide a connected system for transferring water from the Tocks Island Reservoir to storage in the lower reservoir at Yards Creek, and would result in a net pumping lift of about 450 feet for water supply water. This water could then be delivered by gravity from Yards Creek Reservoir at elevation 810± to Round Valley Reservoir (elevation 385), or to a considerable area of northwest New Jersey by a pressure pipeline. Delivery of this water from Delaware River would involve a minimum of additional cost for structures and no additional pumping equipment would be required. Additional storage would have to be provided in the lower reservoir at Yards Creek by increasing its height about 10 feet to provide for uniform and reliable release of water supply from this reservoir. An overflow weir would be required between the upper reservoir for Tocks Island project and the upper reservoir for Yards Creek. The cost of these additonnal facilities has been estimated by the consulting engineering company at about $260,000.

80. Preliminary studies made by a consultant for the New Jersey Power & Light Company indicate that water can be delivered from Yards Creek to Round Valley Reservoir at a lower cost than under any other plan of diversion. For example, it has been estimated that a pipeline from Yards Creek to Round Valley could be built for approximately the same cost as the pumping plant and pipelines required for diversion from the Delaware River at Frenchtown, New Jersey. However, the pumping costs associated with the Yards Creek supply would be only about half the costs incurred for pumping at Frenchtown, thereby effecting a saving of about $400,000 per year. In addition, the pipeline from Yards Creek could make the water available by gravity to a substantial additional area, including several towns in Warren and Hunterdon Counties along its route. It is understood the New Jersey Department of Conservation and Economic Development is co-operating with the New Jersey Power & Light Company in a further investigation of the use of the combined project to supply Delaware River water to the northwest portion of that State and additional designs and cost estimates are to be prepared in the near future.

81. <u>Additional Sites Considered for Multiple-Purpose Development</u>. Nine additional sites, considered at various stages of the planning studies, were investigated to determine feasibility for development of conventional hydroelectric power. The project data and economic data for these sites are shown in Tables T-21 and T-22. As indicated in Table T-22, eight of these sites are economically infeasible for development of hydroelectric power at this time based on specific power costs. The Bear Creek project (existing single-purpose flood control dam raised to permit multiple-purpose development) shows evidence of economic feasibility based on a 20 percent load factor operation. However, this type of an operation, without some degree of reregulation of flows would not be compatible with present downstream demands for supplies of water. The added cost of reregulation would make the development of peaking power at this site economically infeasible. A base load plant was also investigated at this site. The average annual specific power costs for this type operation (shown in Table T-22) plus the annual separable storage cost of $15,100 charged to power exceed the average annual benefits. The decision to include hydroelectric power facilities at the Bear Creek Project needs to be based on detailed studies reflecting anticipated daily, weekly, and seasonal water supply requirements at the time of development. The proposed modification of the Bear Creek project was indicated in Appendix Q to be some 30 years in the future. The lack of firm foresight as to the nature of water supply requirements in the Lehigh River Basin some 30 years hence, makes it impractical to fully appraise, at this time, the power potential at the Bear Creek project. Such appraisals should be made at a later date when the project is restudied as a basis for requesting authority for the modification of the existing project.

TABLE T-21

APPRAISAL OF CONVENTIONAL POWER AT ADDITIONAL SITES CONSIDERED FOR MULTIPLE-PURPOSE DEVELOPMENT
PROJECT DATA

Project Type of Development	Prompton Peaking with Storage	Bear Creek Peaking with Storage	Bear Creek Base-Load with Storage	Beltzville Peaking with Storage	Aquashicola Peaking with Storage	Trexler Peaking with Storage	Maiden Creek Peaking with Storage	Blue Marsh Peaking with Storage	Newark Peaking with Storage	Christiana Peaking with Storage
Location	Lackawaxen River	Lehigh River	Lehigh River	Pohopoco Creek	Aquashicola Creek	Jordan Creek	Maiden Creek	Tulpehocken Creek	White Clay Creek	Christina River
Drainage area, sq.mi.	60	288	288	75 (a)	66	51	161	174.5	67	41
Reservoir elevation, feet, m.s.l.										
Maximum flood control	1,209	1,484	1,484	647	508	495	398	304	-	-
Maximum power pool	1,185	1,430	1,430	624	490	483	386	283	162	50
Minimum power pool	1,135	1,335	1,335	561	455	440	345	260	125	29
Storage capacity, acre-feet										
Flood control	20,300	108,000	108,000	27,000	20,000	14,000	38,000	33,000	-	-
Power	26,000	70,000	70,000	40,000	24,000	24,200	74,000	14,500	30,000	36,000
Total (b)	55,300	186,000	186,000	76,200	51,000	42,700	128,000	52,000	38,000	40,000
Average tailwater elevation, feet, m.s.l.	1,085	1,240	1,240	496	420	395	300	230	75	3
Net head, maximum feet	100	190	190	128	70	88	86	53	87	47
minimum feet	50	95	95	65	35	45	45	30	50	26
average feet	83	158	158	107	58	74	72	45	75	40
Regulated flow, c.f.s.										
Critical period	66	268	268	105	78	68	176	110	63	46
Average for power	102	500	400	150	130	100	235	250	88	52
Power										
Installed capacity, kw	1,700	11,500	6,500	3,200	1,320	1,500	3,500	1,200	1,200	500
Dependable capacity, kw	1,000	7,000	1,800	1,900	800	900	2,200	800	800	300
Primary energy, kw-hr	3,100,000	21,000,000	26,700,000	5,800,000	2,400,000	2,700,000	[illegible]00,000	2,200,000	2,200,000	900,000
Average annual energy, kw-hr	5,400,000	48,600,000	42,700,000	10,100,000	5,000,000	4,700,000	16,700,000	7,100,000	4,200,000	1,600,000
Load factor in critical period, %	20	20	100	20	20	20	20	20	20	20

(a) Excludes 22 square miles that contribute to Wild Creek Reservoir (Bethlehem, Pa. water supply)
(b) Includes flood control, power and inactive storage

TABLE T-22

APPRAISAL OF CONVENTIONAL POWER AT ADDITIONAL SITES CONSIDERED FOR MULTIPLE-PURPOSE DEVELOPMENT
ECONOMIC DATA

Project	Prompton Peaking with Storage	Bear Creek Peaking with Storage	Bear Creek Base Load with Storage	Beltzville Peaking with Storage	Aquashicola Peaking with Storage	Trexler Peaking with Storage	Maiden Creek Peaking with Storage	Blue Marsh Peaking with Storage	Newark Peaking with Storage	Christiana Peaking with Storage
Construction cost (a)	$570,000	$2,948,000	$2,223,000	$898,000	$531,000	$540,000	$1,153,000	$571,000	$439,000	$262,000
Interest during construction (b)	29,000	147,000	111,000	45,000	27,000	27,000	58,000	29,000	22,000	13,000
Investment for power	599,000	3,095,000	2,334,000	943,000	558,000	567,000	1,211,000	600,000	461,000	275,000
Average annual charges										
Interest and amortization (c)	21,000	109,000	82,000	33,000	19,700	20,000	43,000	21,000	16,300	9,700
Major replacements (d)	1,200	6,000	4,700	1,900	1,100	1,100	2,500	1,200	1,000	600
Operation and maintenance (e)	25,600	63,000	51,000	41,000	19,800	22,500	42,000	18,000	18,000	7,500
Administration (f)	8,900	22,000	17,700	14,300	6,900	7,900	14,600	6,300	6,300	2,600
Insurance (in lieu of)	600	3,000	2,300	1,000	500	600	1,200	600	500	300
Taxes foregone	9,100 (g)	62,500 (g)	16,200 (g)	17,200 (g)	7,100 (g)	8,100 (g)	23,000 (h)	8,200 (h)	8,200 (h)	3,400 (h)
Total	65,800	265,500	173,900	108,400	55,100	60,200	126,300	55,300	50,300	24,100
Average benefits										
Dependable capacity	19,300 (i)	134,800 (i)	34,700 (i)	36,600 (i)	15,400 (i)	17,300 (i)	54,600 (j)	19,800 (j)	19,800 (j)	8,200 (j)
Interruptible capacity	6,700 (k)	43,300 (k)	11,500 (k)	12,500 (k)	5,000 (k)	5,800 (k)	16,100 (l)	5,000 (l)	5,000 (l)	2,100 (l)
Energy	17,600 (m)	158,000 (m)	138,800 (m)	32,800 (m)	16,300 (m)	15,300 (m)	34,200 (n)	22,700 (n)	13,500 (n)	5,200 (n)
Total	43,600	336,100	185,000	81,900	36,700	38,400	104,900	47,500	38,300	15,500
Average annual net benefits	-22,200	70,600	11,100	-26,500	-18,400	-21,800	-21,400	- 7,800	-12,000	- 8,600

(a) Power facilities only.
(b) 4-years at 2.5 percent.
(c) Interest 2.5 percent, amortization 50 years 1.026 percent = 3.526 percent.
(d) 0.20 percent of total investment.
(e) Average cost curves from manual
(f) 35 percent of operation and maintenance.
(g) ($6.75/kw x dependable cap.) + ($3.38 x interruptible capacity)
(h) ($8.21/kw x dependable cap.) + ($4.10 x interruptible capacity)
(i) $19.26/kw-based on installed alternative steam cost of $140/kw for this locality.
(j) $24.80/kw-based on installed alternative steam cost of $170/kw for this locality.
(k) $9.63/kw
(l) $12.40/kw
(m) 3.25 mills per kw-hr
(n) 3.2 mills per kw-hr

IX POWER INSTALLATIONS CONSIDERED IN COMPREHENSIVE PLAN

82. Sites Considered.

Preliminary hydroelectric power appraisals, discussed in preceding sections, show that conventional type power development appears economically feasible, based on specific power costs, at the following sites: Hawk Mountain, Knights Eddy, Wallpack Bend, Tocks Island and Lackawaxen. Pumped storage development appears economically feasible at the Tocks Island and Yards Creek sites. All of the above-mentioned sites were considered as potential multiple purpose projects with the exception of the Yards Creek project which would be a pure pumped storage development and would have little or no effect on other uses of the water resources of the basin.

83. Studies were performed to determine which of the multiple purpose projects considered in the preliminary plans could be most economically integrated into a final comprehensive plan for the development of the water resources of the Delaware Basin. This comprehensive plan would have to develop a balanced program to meet the needs of the basin through the year 2010, with respect to water supply, flood control, recreation, power and other uses. Details of these studies are discussed in Appendix Q - FORMATION OF PLAN OF DEVELOPMENT. From the results obtained in benefit-cost studies, a final optimum comprhensive plan was formulated. This final plan included two sites previously determined to be economically feasible for hydroelectric power development, Hawk Mountain site on East Branch, Delaware River, and the Tocks Island site on Delaware River.

84. Since the Yards Creek project would have little or no effect on the development and use of the water resources of the basin, further consideration of this independent potential development has not been undertaken as a part of this investigation. Recent studies by non-Federal interests have indicated the economic feasibility of this development. However, because of its relative independence from water resources development, further detailed investigations of pumped storage at the Yards Creek site have been omitted.

85. Determination of Average Annual Charges.

Subsequent to the selection of the sites to be included in the comprehensive plan of development, a more detailed analysis of the estimated average annual power charges was required. The following method was used to determine the average annual charges for all subsequent schemes to develop conventional hydroelectric power at Tocks Island and Hawk Mountain projects. These average annual charges were required for comparison with average annual benefits from the hydroelectric power produced. In order to provide a consistent

appraisal of all multiple-purpose project features for use in subsequent cost allocation studies, a low risk interest rate was used to analyse all project features, including hydropower. The investment required for both the Tocks Island and Hawk Mountain power facilities included the estimated first cost, plus interest on this cost during the construction period. The interest was taken as 2.5 percent per year, and the construction period for the power facilities estimated at four years for each project. Average annual charges included amortization of this investment, annual operation and maintenance charges, interim replacements, insurance (in lieu of), as well as administrative and general expenses, and estimated taxes foregone.

a. Amortization. Each project would have a 50-year economic life during which the initial investment for power facilities would be repaid. For Tocks Island and Hawk Mountain projects the amortization rate required for a 50-year amortization period with interest at 2.50 percent, is 1.026 percent of the total initial investment.

b. Interim Replacements. Interest and amortization charges on the initial investment do not provide for replacement of those plant items of property whose life span would be less than 50 years, therefore, an allowance must be made for financing the cost of such shorter-lived items. The Federal Power Commission recommends an annual allowance, equivalent to 0.20 percent of the total initial investment on a straight line basis be used to cover interim replacements over the assumed 50-year amortization period. This value was used for both plants.

c. Insurance. Federal projects are actually considered as "self-insured" but insurance constitutes a real cost and an annual allowance equivalent to 0.10 percent of the initial investment has been adopted as reasonable for both projects.

d. Operation and Maintenance Costs. The Federal Power Commission 1/ has published estimates of total annual operation and maintenance costs for typical hydroelectric plants ranging in size from 2,500 to 1,500,000 kilowatts of installed capacity. These costs appeared to be representative of local conditions and no adjustments were made for either of the two plants. The published values for

1/ Federal Power Commission - Instructions for Estimating Electric Power Costs and Values. Bureau of Power, Technical Memorandum No. 1, Washington 25, D. C., 7 May 1958.

operation and maintenance were plotted against the plant capacities and values for Hawk Mountain and Tocks Island plants determined from the resulting relationship. (See plate T-4).

e. Administrative and General Expenses. The Federal Power Commission 1/ has recommended that an annual allowance equivalent to 35 percent of the total operation and maintenance costs, as determined above, be included in annual charges to cover administration and general expenses for hydroelectric powerplants. This allowance was used for both Hawk Mountain and Tocks Island plants.

f. Taxes Foregone. Taxes foregone is a term used to designate the amount of taxes which would not be collected as a result of a Federal or public power development rather than the most likely private alternative development. In project feasibility studies taxes foregone are included in the economic cost of hydroelectric projects. Appendix F 2/ to the basic report, prepared by the Federal Power Commission, lists the capital costs per kilowatt for alternative steam electric plants in the vicinity of both Hawk Mountain and Tocks Island and also lists the percent of investment charged to taxes at these two alternative steam power sites. These values were used herein for both Hawk Mountain and Tocks Island hydroelectric plants to determine annual charges due to taxes foregone.

86. Value of Hydroelectric Power. The final capacity and energy values for the power produced at the Hawk Mountain and Tocks Island sites were determined in power valuation studies made by the Federal Power Commission and discussed in Appendix F.2/ As previously stated, prior to the determination of the final selected power installation at these two sites, the evaluation of these facilities has been based upon the cost and value of power at the low-tension bus bars for both the hydroelectric plants and the alternative steam electric plants. Therefore, designs and estimates for the step-up substation at the hydro plant have been omitted from the initial detailed investigations at Hawk Mountain and Tocks Island. These items were also omitted by the Federal Power Commission in determining the cost of producing the equivalent amount of power by the alternative steam electric plants except that it was determined that the cost of transmission would

1/ Ibid.
2/ Appendix F - POWER MARKET AND VALUATION OF POWER. Prepared by the Federal Power Commission, New York, N. Y.

be approximately the same from the hydroelectric plants as from the steam plants. The following are the unit costs of power at the low tension bus bar of the alternative steam-electric plants for Hawk Mountain and Tocks Island.

Item	Unit	Tocks Island	Hawk Mountain
Unit Capacity Value	$/kw.	24.80	24.50
Unit Energy Value	mills/kw.-hr.	3.2	3.1

Upon the selection of the final proposed power installations at Hawk Mountain and Tocks Island the estimates for the step-up substation have been included both in the hydro and alternative steam costs. The following are the unit costs of power at the high tension bus bar of the alternative steam electric plants for the two sites.

Item	Unit	Tocks Island	Hawk Mountain
Unit Capacity Value	$/kw.	28.00	29.00
Unit Energy Value	mills/kw.-hr.	3.2	3.1

87. Tocks Island Project.

Hydroelectric power would be developed at the Tocks Island site by the construction of a conventional type powerplant on the left bank of Delaware River below Tocks Island dam. Investigations of this development considered initially two types of installations, one for production of continuous power for use on base load, and the other for production of power with about a 20 percent load factor. Operation of the first type would be consistent with potential releases from the Tocks Island reservoir for low flow augmentation. The second type would require a reregulating afterbay to provide for releases during offpeak periods, and to prevent downstream damage from river stage variations of 5-6 feet caused by the intermittent high discharges required for load factor operation.

88. Storage Allocation and Water Available. Preliminary maximization studies for Tocks Island indicated storage allocations of 415,000 acre-feet of long-term storage for water supply, recreation and power, and 200,000 acre-feet of short-term storage for flood control. The following storage allocations were used for detailed studies of the two types of development initially considered at Tocks Island: 20,000 acre-feet of inactive storage to elevation 334, 415,000 acre-feet of water supply, recreation and power storage to elevation 405; and 200,000 acre-feet of flood control storage to elevation 420. The water supply reservoirs, serving New York City, were

assumed to be operated to release flows in accordance with the 1954 amended decree of the United States Supreme Court. The gross minimum yield at Tocks Island from the New York City reservoir contribution, the drainage area above the site and the 415,000 acre-feet of water supply, recreation, and power storage was estimated at 2,780 cubic feet per second. Upon completion of the Hawk Mountain project with an additional 290,000 acre-feet of long term storage the gross minimum yield at Tocks Island would be increased to 3,270 cubic feet per second. Construction of this project for low flow augmentation contemplated operating the Tocks Island reservoir from elevation 405 down to elevation 334 to provide the guaranteed yield throughout the most critical drought period. Preliminary operation studies, covering a 53-year period indicated, however, that the reservoir would be drawn below elevation 385 only about five percent of the time in this period.

89. Base Load Operation. Prior to determination of a time schedule for construction of projects in the basin plan it was considered desirable to design the base load plant at Tocks Island on the 3,270 cubic feet per second gross minimum yield which includes use of 290,000 acre-feet of upstream storage at Hawk Mountain. Normal tailwater at the powerplant would be at elevation 302 feet, and the extreme drawdown for low flow augmentation would result in a minimum head of only 32 feet. The maximum head with full reservoir would be 103 feet. The minimum head under these conditions represents a drawdown of 69 percent of the maximum head It is impracticable to design a power unit to operate under this wide head variation. However, preliminary operation studies indicate that the gross minimum yield of 3,270 cubic feet per second could be supplied over 95 percent of the time by drawing the reservoir only to elevation 385 feet. This would require the reservoir to be drawn below this level less than five percent of the time to provide the gross minimum yield. The powerplant was therefore designed to operate with a total drawdown of 20 feet from elevation 405 to 385. The plant would have a minimum head of 83 feet, a maximum head of 103 feet and an average head, as determined from preliminary operation studies of 96 feet. Dependable capacity (95 percent dependable), based on the minimum head of 83 feet, would be 20,000 kilowatts. Installed capacity based on the average head of 96 feet would be 23,000 kilowatts. Average annual energy produced from this installation would be 188.4 million kilowatt-hours. Designs and cost estimates were made to determine the specific costs and annual charges for this installation. Table T-23 summarizes the costs and benefits and shows a net annual benefit from this scheme of $594,000. The term "net annual benefit" as used herein is the difference between the average annual power benefits derived from the installation and the average annual specific costs of including the power installation as a purpose in the multiple purpose project. Therefore, the figures given herein

as net annual benefits permit comparisons between various schemes of power development, but do not indicate the final economic benefits which are discussed in Appendix V - BENEFITS AND COST ALLOCATIONS. Since the Tocks Island reservoir would be full and spilling over 50 percent of the time as determined from preliminary operation studies a second 23,000 kilowatt unit was added to make use of this extra water when available. Average annual energy produced from this 46,000 kilowatt installation would be increased to 272.1 million kilowatt-hours. Specific power costs and benefits for this installation were estimated and are shown in Table 23. This scheme resulted in a net annual benefit of $638,000.

90. Load Factor Operation. Facilities to produce power, when operating at about a 20 percent load factor, were also considered for this site. These facilities would be designed to utilize the gross minimum yield of 2,780 cubic feet per second, determined for the site prior to the construction of the Hawk Mountain reservoir. The power facilities would consist of an intake structure with entrance channel located above the dam; four reinforced concrete and steel penstocks constructed under the left end of the dam; and a powerplant and tailrace constructed below the dam. Load factor operation of Tocks Island powerplant would result in a wide variation in flows and the generation of floodsurges below the plant each time the plant is placed in operation. The use of water from Tocks Island reservoir for water supplied by flow augmentation to meet the needs of the Trenton-Wilmington demand reach downstream would require an essentially even flow throughout each day of the week. Use of downstream reaches of the river for recreation and fish and wildlife conservation, would make the passage of large flood surges undesirable. Communication with other State and Federal agencies indicated that a reregulating pond, or afterbay, should be included as a part of the power facilities required for the initial load-factor project at Tocks Island. Physical conditions and cultural development below the Tocks Island site make the provision of such an afterbay difficult and expensive. The nearest suitable location for the impounding weir appears to be near the lower end of the Delaware Water Gap at mile 209.6, and about 2.4 miles above the Portland-Columbia Highway Bridge. A weir would be constructed across the river at this point to provide a pool with a top elevation at 310 feet. The pond would extend about 7.8 miles upstream to the Tocks Island powerplant where normal tailwater would rise to about this same elevation during peaking power operation. The capacity of the pond would be 15,500 acre-feet which would be sufficient to reregulate the peaking discharges from the power installation. The area of this pond when filled to elevation 310 would be about 1,000 acres, most of which would be within the present banks of Delaware River. The powerplant would be designed to utilize a 20-foot drawdown in the Tocks Island reservoir between elevations 405 and 385. It would be capable of operation at greater drawdowns but at reduced efficiencies. Normal tailwater would be at elevation 310.

TABLE T-23

SUMMARY OF INVESTIGATIONS - TOCKS ISLAND PROJECT
CONVENTIONAL POWER
Preliminary Investigations

	Base Load	With Hawk Mountain	Increment 23,000 kw. to 46,000 kw.	Peaking (a)	Increment 46,000 kw. to 91,000 kw.	Final Adopted Plan without Substation	Step-up Substation Facilities for Final Adopted Plan	Final Adopted Plan Including Substation
PROJECT DATA								
Location - River	Delaware	Delaware		Delaware		Delaware		
Miles above Delaware Capes	217.4	217.4		217.4		217.4		
Drainage area, sq. mi. (b)	2,912	2,912		2,912		2,912		
Storage, acre-feet								
Flood control	200,000	200,000		200,000		275,000		
Water supply	415,000	415,000		415,000		410,000		
Minimum flow, c.f.s. regulated	3,270	3,270		2,780+		2,780		
Elevation, feet, m.s.l.								
Maximum flood control pool	420	420		420		428		
Maximum power pool	405	405		405		410		
Minimum power pool	385 (c)	385 (c)		385 (c)		356 (d)		
Minimum water supply pool	334	334		334		356		
Tailwater (average)	302	302		310		303		
POWER DATA								
Head, feet								
Maximum	103	103		95		107		
Average	96	96		88		103		
Minimum	83 (c)	83 (c)		75 (c)		53 (d)		
Installed capacity, kw.	23,000	46,000 (e)		91,000		46,000		
Dependable capacity, kw.	20,000	20,000		72,000		20,000 (a)		
Interruptible capacity, kw.	3,000	3,000		19,000		26,000		
Average annual generation, million kw.-hr.	188.4	272.1		313.2		281.5		
Type turbines	Fixed Blade	Fixed Blade		Fixed Blade		Kaplan		
COST								
Power facilities at dam	$6,191,000 (f)	$10,548,000 (f)		$24,401,000 (f)		$11,823,000 (f)		
Reregulating dam	0	0		12,726,000		0		
Total	6,191,000	10,548,000		37,127,000		11,823,000		
Interest during construction (g)	309,500	528,000		1,856,000		591,000		
Total investment	6,500,500	11,076,000		38,983,000		12,414,000	$511,000	$12,925,000
AVERAGE ANNUAL CHARGES								
Interest and amortization	229,000 (h)	390,500 (h)		1,374,500 (h)		438,000 (h)	22,000 (i)	460,000
Major replacements	13,000 (j)	22,000 (j)		78,000 (j)		25,000 (j)	1,700 (k)	27,000
Operation and maintenance	87,500 (l)	124,000 (l)		247,500 (l)		129,000 (l)	24,000 (m)	153,000
Administration	30,500 (n)	43,500 (n)		70,000 (n)		45,000 (n)	4,800 (o)	50,000
Insurance (in lieu of)	6,500	11,000		39,000		12,000	1,000	13,000
Taxes foregone	175,000 (p)	175,000 (p)		669,000 (p)		271,000 (p)		335,000 (q)
Total	542,000	766,000	$224,000	2,478,000	$1,712,000	920,000		1,038,000
AVERAGE ANNUAL BENEFITS								
Dependable capacity	496,000 (r)	496,000 (r)		1,786,000 (r)		496,000 (r)		560,000 (s)
Interruptible capacity	37,000 (t)	37,000 (t)		235,000 (t)		322,000 (t)		364,000 (u)
Energy	603,000 (v)	871,000 (v)		1,002,000 (v)		901,000 (v)		901,000 (v)
Total	1,136,000	1,404,000	$268,000	3,023,000	$1,619,000	1,719,000		1,825,000
Average annual net benefits	594,000	638,000	44,000	545,000	-93,000	799,000		787,000

(a) 20% load factor
(b) Excludes area above three reservoirs which divert water for New York City
(c) 95% of time
(d) 100% of time
(e) Additional 23,000 kw. for use when reservoir is full and spilling
(f) Does not include step-up substation
(g) 4 years at 2.5%
(h) Interest 2.5%, amortization 50 years 1.026% = total 3.526%
(i) Interest 2.5%, amortization 35 years 1.82% = total 4.32%
(j) 0.20% of total investment
(k) 0.35% of total investment
(l) Average cost curves from manual
(m) Average cost curves for substations from manual
(n) 35% of operation and maintenance
(o) 20% of operation and maintenance
(p) ($8.20/kw. x dependable cap.) + ($4.10/kw x interr. cap.)
(q) ($10.15/kw. x dependable cap.) + ($5.08/kw. x interr. cap.)
(r) $24.80/kw.
(s) $28.00/kw.
(t) $12.40/kw.
(u) $14.00/kw.
(v) 3.2 mills per kw.-hr.

Average pool level would be at elevation 398. As previously stated for the base load plant, reservoir levels would equal, or exceed, elevation 385 over 95 percent of the time. An installed capacity of 91,000 kilowatts was selected for this plant, based on the above reservoir conditions. This installation would provide a dependable capacity (95% dependable) of 72,000 kilowatts at the minimum head of 75 feet. Average annual energy would be 313.2 million kilowatt-hours. Specific power costs and benefits for this installation were estimated and are shown in Table T-23. This scheme resulted in a net annual benefit of $545,000.

91. Final Adopted Installation. The initial detailed power investigations at Tocks Island indicated that the maximum net benefits will be realized from the 46,000 kilowatt base load installation, as compared to the 91,000 kilowatt load factor plant. This condition is primarily caused by the necessity of including the expensive reregulating afterbay with the load factor plant. Therefore the prime consideration in determining the final adopted installation at Tocks Island would be a plant generating the maximum amount of power without the necessity of including a reregulating afterbay. Final maximization studies for Tocks Island indicated storage allocations of 410,000 acre-feet of long-term storage for water supply, recreation and power and 275,000 acre-feet of short-term storage for flood control. The following storage allocations were used for the final detailed power studies: 80,000 acre-feet of inactive storage to elevation 356. 410,000 acre-feet of water supply, recreation and power storage to elevation 410, and 275,000 acre-feet of flood control storage to elevation 428.

92. Plant Operation and Capacity. The gross minimum yield made available by the 410,000 acre-feet of long term storage is 2,780 cubic feet per second. By the terms of the 1954 amended decree of the United States Supreme Court, the New York City Board of Water Supply reservoirs in the upper Delaware Basin are required to maintain a minimum flow of 1,750 cubic feet per second in the Delaware River at Montague, New Jersey, just upstream from the Tocks Island dam site. This minimum flow at Tocks Island based on the increased drainage area is about 1,800 cubic feet per second. The final scheme for operation of the Tocks Island powerplant would maintain not less than 1,800 cubic feet per second minimum release from the powerplant at all times. The assumed operation would provide an augmented flow in the river on Saturday and Sunday equivalent to the gross minimum yield of 2,780 cubic feet per second. Peaking power would be generated 35 hours a week (about a 20 percent weekly load factor) with the remaining water available. The flow available for peaking under these conditions would be 1,075 cubic feet per second continuous or 5,160 cubic feet per second for peak operation. The extremes of flow from this type operation would be between 1,800 cubic feet per second minimum

to 5,160 cubic feet per second, maximum (when the reservoir was less than full) which represents difference in river stages just downstream from the site of about 1.5 feet. This peaking release when related to stages at Trenton results in river stage variation of about 0.5 feet. This method of powerplant operation is more compatible with water supply and recreational requirements for the site and eliminates the need for costly reregulating facilities. Normal tailwater at the powerplant would be at elevation 303 feet. The maximum head with full reservoir would be 107 feet, minimum head 53 feet and average long term head of 103 feet. Dependable capacity, based on the minimum head of 53 feet would be 20,000 kilowatts. Installed capacity based on a wheel capacity of 6,000 cubic feet per second and average head of 103 feet would be 46,000 kilowatts.

93. Intake Facilities. Construction of an earth fill dam at Tocks Island site would require the use of two 22-foot conduits for diversion during the construction period. These conduits with the appurtenant intake facilities would be available for use as power intakes. The diversion conduits would be constructed in a trench excavated on the left side of the site and would have a total length of about 770 feet from the intake structure to their point of discharge below the dam. The invert of these conduits would be at elevation 305 at their intake and at elevation 300 at their lower end. A discharge channel would be excavated below the lower end of these conduits.

94. Power Penstocks. The conventional powerplant at Tocks Island site would require the installation of two units each with a capacity of 23,000 kilowatts. Each of these units would require a 22-foot inside diameter steel penstock. These steel sections would extend from the axis of the dam to the powerplant constructed to use the downstream 410 feet of the diversion conduits. All but the last 20-foot section of these steel penstocks would be installed at the time the diversion conduits were constructed and would provide the inside form for the downstream portion of these conduits. A study was required to determine whether surge tanks should be included in plans for Tocks Island with 22-foot conduits about 800 feet in length. Studies indicate that there is no rule of thumb for establishment of maximum permissible velocity without need for surge tank. Current practice at projects comparable to Tocks Island is indicated by the data shown in Table T-24 which includes three TVA projects and three Corps of Engineers projects. It is noted that Nottely and Chatuge projects with penstocks over 700 feet long and velocities of 10 to 12 feet per second do not have surge tanks. On the other hand, Fort Randall and Tenkiller Ferry projects with velocities of over 13 feet per second and tunnels over 600 feet long do have surge tanks. A conclusion has been reached for Tocks Island project to omit surge tanks in this survey on the basis that the velocity in the penstocks will not exceed 10 feet per second and for the following additional reasons:

TABLE T-24

PROJECTS HAVING PENSTOCKS COMPARABLE TO THOSE PROPOSED FOR TOCKS ISLAND

Project	Penstock Diam. ft.	Penstock Length ft.	Installed Capacity per Penstock, kw.	Average Head ft.	Turbine Q, c.f.s.	Penstock Velocity, ft./sec.	Surge Tank Constructed	Date Completed
Corps of Engineers								
Fort Randall	22(1)	692(1)	40,000(2)	110(2)	5,050(3)	13.3	yes	1954
Denison	20(1)	800-837(1)	35,000(2)	92.2(2)	5,270(3)	16.8	yes	1945
Tenkiller Ferry	19(1)	649(1)	34,000(2)	123.3(2)	3,820(3)	13.5	yes	1954
Tennessee Valley Authority								
South Holston	15(concrete)	240	-	257	3,020	17.1	yes(4)	1951
	15(steel)	590						
	14(steel)	310						
	Total	1,140						
Nottely	15(concrete)	409	-	1,745	1,770	10.0	no	1955
	12(steel)	330						
	Total	739						
Chatuge	12(steel)	769.5	-	-	1,400	12.4	no	1954

(1) From "Tabulation of Pertinent Data - Flood Control and Multiple Purpose Reservoirs," OCE, May 1951.
(2) From "U. S. Army, Corps of Engineers, Civil Works, Hydroelectric Power, OCE."
(3) Computed using installed capacity, average head and 85 percent efficiency.
(4) Need for surge tank marginal, but was provided.

TABLE T-24

a. The fact that the Tocks Island plant would be a small part of the system load and the fact that there would be sufficient regulation in such a large system that minor load changes would not induce hydraulic instability at Tocks Island.

b. For load on - load off condition, the governor time could exceed the customary five seconds. On two recently constructed projects with about the same head as Tocks Island and somewhat longer penstocks, governor times of 12 and 20 seconds were finally adopted to the satisfaction of the utility company. No surge tanks were provided at either of these two projects. However, cost and benefit information has been reviewed and it has been determined that possible later inclusion of surge tanks would not alter the finding of economic justification for the conventional power installation at Tocks Island.

95. Powerplant. The powerplant would be located on the left bank of the river with its axis approximately parallel with that of the dam. It would be constructed in the diversion channel with its foundations excavated to solid rock. Two adjustable blade Kaplan turbines each with a rating of 33,000 horsepower at best head would be installed in this plant. Each would be direct-connected to a 23,000 kilowatt generator.

a. Substructure. The substructure of the powerplant would be constructed of massive concrete with steel reinforcing placed around various openings as required. It would consist of two main bays, each of which would contain a 33,000 horsepower unit complete with turbine and scroll case. A service bay, of the same size as one of the main bays, would be constructed on the abutment side of the powerplant for use in maintenance and repair of the units. Each of the bays would be 90 feet wide and 50 feet long. The top of the substructure would form the generator floor of the powerplant and would be at elevation 330 feet. Each of the two units in the substructure would have a 4 x 6 foot bypass for use when the units were undergoing maintenance or repair.

b. Superstructure. A reinforced concrete superstructure would be constructed over all three powerplant bays. It would have a clear height of 35 feet over all three bays to permit installation and operation of an overhead traveling crane, required for installation and maintenance of the power units.

c. Tailrace. The diversion channel used during the construction period would be constructed to necessary dimensions to provide a tailrace for the powerplant.

96. Powerplant Access Road. An access road to the Tocks Island powerplant would be constructed at elevation 330 on the dowstream side of Tocks Island Dam. It would extend about 1,000 feet along the dam and about 2,000 feet additional, below the dam on the right bank of Delaware River. It would connect with the existing road to the dam site.

Paving would be heavy-duty type, designed to transport the largest pieces of power equipment to the powerplant.

97. Switchyard and Transformers.

The step-up substation would be located adjacent to the powerhouse on a raised section of the toe of the main embankment. The substation would be of the outdoor type consisting of 110 kilovolt, three-phase transformers with associated switching and protective equipment. Two transformers, each rated at 25,000 kilovolt-ampere, would be required for the 46,000-kilowatt installation at Tocks Island.

98. Cost of Project. Survey-type designs and cost estimates were made for the conventional power installation at Tocks Island site. The general features of these designs, as described above, are shown on plate T-8. Cost estimates are shown in Appendix U, Project Design and Cost Estimates. A summary of these estimates, including allowances for contingencies, engineering, design, and administration is as follows:

CONVENTIONAL POWER FACILITIES - TOCKS ISLAND

Penstocks	$ 735,000
Powerplant	10,967,000
Tailrace	81,000
Access Road	40,000
Substation	511,000
Total	$12,334,000

Table T-23 summarizes the specific power costs and benefits and shows an annual net benefit from this power installation of $787,000.

99. Pumped Storage.

As previously discussed in sections 73-76, preliminary investigations indicated that pumped storage would be feasible for development at the Tocks Island project. It was indicated that Scheme B (pumping from and generating into Tocks Island reservoir) appeared more favorable than Scheme C (pumping from Tocks Island reservoir and generating into Delaware River). Scheme A is eliminated from consideration upon the construction of the Tocks Island project. Inclusion of pumped storage (as developed in Scheme B) as a function of the Tocks Island project was further investigated. A revision of the design and cost estimates previously presented in section 73 was prepared in order to take into account the modifications in the location and design of the Tocks Island project subsequent to preparation of the preliminary pumped storage estimates. The major modification was the relocation of the spillway from the Pennsylvania side to the New Jersey side of

the river as a result of more extensive geologic investigations at the Tocks Island site. Relocation of the spillway to the New Jersey side of the river presented some definite space limitations upon the pumped storage powerplant. In order to construct the four-unit powerplant below the dam on the left bank, it would be necessary to place the spillway about 50 feet farther into the relatively steep slope on the left bank. This additional spillway cost would add to the cost of the pumped storage function. A powerplant with only three units of the size previously considered was also investigated. The three-unit plant would eliminate the additional spillway costs but would use less than the optimum upper level storage. The unit cost for the three-unit plant and the unit cost for the four-unit plant including the additional spillway cost is approximately the same. The possibility of an underground powerplant set back into the hill upstream from the spillway channel was also considered feasible. This underground plant could be built separately in the future after the Tocks Island Dam is completed or before completion of the main dam since it would not interfere with the spillway location. Underground stations are usually as low in cost as conventional stations. The decision as to which powerplant location provides optimum development will require reexamination when a definite project design is undertaken. The scheme presented herein and shown on plate T-8 is the pumped-storage powerplant with provision for four reversible pump-turbine units, located upstream from the spillway and about 1200 feet upstream from the centerline of the dam. The physical characteristics of the Tocks Island pumped-storage project have been previously presented in table 18, Scheme B, with the exception of the subsequent changes in Tocks Island pool levels from elevation 395 maximum to 410 maximum and elevation 360 minimum to 356 minimum.

100. Cost of Project. Survey-type designs and cost estimates were made for the 366,000 kilowatt pumped storage power installation at Tocks Island site. The general features of these designs are shown on plate T-8. Cost estimates are shown in Appendix U, Project Design and Cost Estimate. A summary of these estimates, including allowances for contingencies, engineering, design, and administration is as follows:

TOCKS ISLAND
PUMPED STORAGE POWER FACILITIES

Lands & Damages, upper res.	$	46,000
Reservoir Clearing, upper res.		55,000
Tailrace and Discharge Structure		5,353,000
Powerplant, incl. equipment		19,055,000
Substation		4,736,000
Tunnel, Penstock and Valves		13,923,000
Intake, upper res.		1,014,000
Dikes		8,739,000
Access Road		928,000
Total		53,849,000

The above estimate differs from any estimate shown in table-19 for the following reasons: locating the powerplant upstream from the spillway channel, inclusion of upper reservoir land and clearing costs, and use of higher percentages for engineering and design, and for supervision and administration costs in this estimate to conform to other estimates included in Appendix U. Table T-25 summarizes the annual specific power costs and benefits. It is shown that the annual cost per kilowatt of Kittatinny Mountain pumped storage, including 2,000 hours of peak load generation, is $23.70. The value of this service as measured on the private utility system, by the cost of alternative new steam capacity is estimated to be $30.99 per kilowatt per year. Table T-26 summarizes the project data and economic data for the Tocks Island pumped storage project. In order to determine the economic merit of a pumped-storage project, for a specific situation, additional cost comparisons would have to be made on the basis of peaking thermal capacity or other potential single-purpose pumped-storage developments in the general area.

101. Hawk Mountain Project. Hydroelectric power would be developed at the Hawk Mountain site by the construction of a conventional type powerplant on the left bank of the East Branch, Delaware River, about 500 feet below the axis of the proposed Hawk Mountain dam. Investigations of this development considered initially two types of installations, one for production of continuous power for use on base load, and the other for production of power with about a 20 percent load factor. Operation of the first type would be consistent with potential releases from Hawk Mountain reservoir for other purposes. The second type would require a reregulating afterbay to prevent downstream damage from high discharges required by load factor operation. Preliminary analyses, similar to those described for the Tocks Island site were performed for the Hawk Mountain base load and load factor plants. Project data and costs and benefits for these two plants are summarized in table T-21.

102. Base Load Plant. Average annual specific power costs and average annual benefits shown in table T-27 for the 8,600 kw. installed base load plant indicates a value of $164,000 average annual net benefit for this installation.

TABLE T-25
COMPARISON OF COSTS AND BENEFITS -
TOCKS ISLAND PUMPED STORAGE PROJECT

(All values in dollars per kilowatt installed)

	Pumped Storage	Alternate Steam
Installed cost - plant	$155	$170
Installed cost - transmission	Assume the same for both hydro and steam	
Annual capacity costs		
Fixed charges - 3.93% hydro	6.09	-
Fixed charges - 12.33% steam 1/	-	20.96
Taxes foregone - 4.83% of steam installed cost	8.21	
Operation and Maintenance	1.20	2.00
Administrative & General Expenses	0.40	0.50
Cost of Fuel Inventory	-	0.10
Allowance for greater unavailability of steam, 5% of other capacity costs	-	1.18
Subtotal - capacity costs	15.90	24.74
Fuel costs (incl. incremental maint.) steam 4,500 hours @ 3.5 mills		15.75
Pumping energy for 2,000 hours, use of generation (3,000 kw.-hr/KW @ 2.6 mills) 2/	7.80	-
Additional steam generation for 2,500 hours @ 3.8 mills	9.50	-
Subtotal - energy costs for 4,500 hours	17.30	15.75
Deduct, Additional steam cost necessary to match, hydro service (2,000 hrs.) with steam (4,500 hours)	(9.50)	(9.50)
Net cost of energy for 2,000 hours	7.80	6.25
Total capacity and energy costs with 2,000 hours of generation	23,70	30.99

1/ Includes all taxes - 4.83 percent of investment. (A portion of these are revenue taxes that must be paid regardless of the source of generation).

2/ 2.6 mills assumed for this analysis only and determined by Power Work Group. The cost of the pumping energy depends not only on existing steam costs, but on the trend of future fuel costs for new steam capacity. As long as low cost energy is available from system plants in low cost fuel areas, there appears to be no substantial penalty attached to the pumping operation.

TABLE T-26
PROJECT & ECONOMIC DATA - TOCKS ISLAND
PUMPED STORAGE PROJECT

Project Data	Tocks Island Dam & Reservoir	Kittatinny Mt. Upper Reservoir
Location - River	Delaware	-
Miles above Delaware Capes	217.4	-
Drainage area, sq. mi. (a)	2,912	-
Storage, acre-feet		
Flood Control	275,000	
Water supply & power	410,000	7,500
Minimum flow, c.f.s. regulated	2,780	-
Elevation, feet m.s.l.		
Maximum flood control pool	428	-
Maximum power pool	410	1,545
Minimum power pool	356	1,480
Minimum water supply pool	356	-

Power Data	
Head, feet (net)	
Maximum	1,142
Average	1,100
Minimum	1,027
Discharge at average head, c.f.s.	4,600
Installed capacity, kw.	366,000
Dependable capacity, kw.	342,000
Interruptible capacity, kw.	24,000
Average annual generation, million kw.-hr.	732
Generating time per week, hrs.	42
Cost	
Power facilities	$53,849,000
Interest during construction (b)	2,692,000
Total	$56,541,000
Average Annual Charges	
Interest and amortization (c)	$ 1,994,000
Major replacements (d)	113,000
Operation and maintenance (e)	439,000
Administration (f)	146,000
Insurance (in lieu of) (g)	113,000
Taxes foregone (h)	2,906,000
Economic cost of land	2,400
Pumping cost (i)	2,855,000
Total	$ 8,568,400
Average Annual Benefits	
Dependable capacity (j)	$ 8,461,000
Interruptible capacity (k)	297,000
Energy (l)	2,288,000
Total	$11,046,000

(a) Excludes area above three reservoirs which divert water for New York City.
(b) 4 years at 2.5%.
(c) Interest 2.5%, Amortization 50 years 1.026% = total 3.526%.
(d) 0.20% of total investment.
(e) $1.20/kw. as determined by Power Work Group.
(f) 35% of operation and maintenance ($0.40/kw.)
(g) 0.20% of total investment.
(h) ($8.21/kw. x dependable cap.) + ($4.105/kw. x interr. cap.)
(i) 1,098 million kw.-hr. x 2.6 mills/kw.-hr.
(j) $24.74/kw.
(k) $12.37/kw.
(l) 3.125 mills/kw.-hr.

TABLE T-27

SUMMARY OF INVESTIGATION - HAWK MT. PROJECT

	Base Load	Peaking (a)	Increment 8,600 kw. to 42,000 kw.	Final Adopted Plan	Step-up Substation Facilities for Final Adopted Plan	Final Adopted Plan Including Substation
PROJECT DATA						
Location - River	East Branch Delaware					
Miles above mouth	7.8	7.8		7.8		
Drainage area, sq. mi. (b)	440	440		440		
Storage, acre-feet						
Flood Control	0	0		0		
Water supply	290,000	290,000		233,000		
Minimum flow, c.f.s. regulated	880	880		820		
Elevation, feet m.s.l.						
Maximum flood control pool	-	-		-		
Maximum power pool	1,082	1,082		1,082		
Minimum power pool	1,045 (c)	1,045 (c)		1,008 (d)		
Minimum water supply pool	950	950		1,008		
Tailwater (average)	934	937		934		
POWER DATA						
Head, feet						
Maximum	148	145		148		
Average	136	133		136		
Minimum	111 (c)	108 (c)		74 (d)		
Installed capacity, kw.	8,600	42,000		21,000		
Dependable capacity, kw.	7,050	33,000		11,000		
Interruptible capacity, kw.	1.550	9,000		10,000		
Average annual generation, million /kw.-hr.	68.8	97.0		93.8		
Type Turbines	Francis	Francis		Francis		
COST						
Power facilities at dam	$2,465,000 (e)	$9,513,000 (e)		$4,847,000 (e)		
Reregulating dam	0	6,298,000		0		
Total	2,465,000	15,811,000		4,847,000		
Interest during construction (f)	123,000	791,000		242,000		
Total investment	2,588,000	16,602,000		5,089,000	$232,000	$5,321,000
AVERAGE ANNUAL CHARGES						
Interest and amortization	91,000 (g)	585,000 (g)		179,000 (g)	10,000 (h)	189,000
Major replacements	5,000 (i)	33,000 (i)		10,000 (i)	800 (j)	11,000
Operation and maintenance	56,000 (k)	156,000 (k)		84,000 (k)	15,800 (l)	100,000
Administration	20,000 (m)	43,000 (m)		29,000 (m)	3,200 (n)	32,000
Insurance (in lieu of)	3,000 (o)	17,000 (o)		5,000 (o)	600 (p)	6,000
Taxes foregone	66,000 (q)	317,000 (q)		135,000 (q)		169,000 (r)
Total	241,000	1,151,000	$910,000	442,000		507,000
AVERAGE ANNUAL BENEFITS						
Dependable capacity	173,000 (s)	809,000 (s)		270,000 (s)		319,000 (t)
Interruptible capacity	19,000 (u)	110,000 (u)		122,000 (u)		145,000 (v)
Energy	213,000 (w)	301,000 (w)		291,000 (w)		291,000 (w)
Total	405,000	1,220,000	815,000	683,000		755,000
Average annual net benefits	164,000	69,000	-95,000	241,000		248,000

(a) 20% load factor
(b) Excludes 3[illegible]3 sq.mi.above Downsville Dam.
(c) 91% of time.
(d) 100% of time.
(e) Does not include step-up substation.
(f) 4 years at 2.5%
(g) Interest 2.5%,amortization 50 yrs. 1.026% = total 3.526%
(h) Interest 2.5%,amortization 35 yrs. 1.87% = total 4.32%
(i) 0.20% of total investment
(j) 0.35% of total investment
(k) Average cost curves from manual
(l) Average cost curves for substations from manual
(m) 35% of operation and maintenance
(n) 20% of operation and maintenance
(o) 0.1% of total investment
(p) 0.25% of total investment
(q) ($8.45/kw. x dep. cap.) + ($4.23/kw. x interr. cap.)
(r) ($10.55/kw. x dep. cap.) + ($5.28/kw. x interr. cap.)
(s) $24.50/kw.
(t) $29.00/kw.
(u) $12.25/kw.
(v) $14.50/kw.
(w) 3.1 mills per kw.-hr.

103. Load Factor Plant. The reregulating weir required for this plant would be constructed across the East Branch, Delaware River, at the Hancock site about 6.2 miles below the Hawk Mountain dam The pond formed by this weir would provide about 5,000 acre-feet of storage for reregulating power releases. This pond at elevation 927 feet would extend upstream about 6.2 miles to the vicinity of the Hawk Mountain powerplant and would have a surface area of about 480 acres, most of which would be within the present riverbanks. As shown in Table T-27 this scheme results in an average net benefit of $69,000.

104. Final Adopted Installation. The initial detailed power investigations at Hawk Mountain indicated that the maximum net benefits will be realized from the 8,600 kilowatt base load installation. As indicated above for the Tocks Island site the prime consideration in determining the final adopted installation at Hawk Mountain would be maximum power generation without the necessity of including a reregulating afterbay. Final storage allocations used for developing the final detailed power studies at Hawk Mountain were as follows: 60,000 acre-feet of inactive storage to elevation 1,008 feet, and 233,000 acre-feet of water supply, recreation and power storage to elevation 1,082 feet. The maximum pool level was economically limited to elevation 1,082 feet by the town of Downsville, New York just below the Pepacton reservoir of the New York City Board of Water Supply.

105. Plant Operation and Capacity. The gross minimum yield made available by the 233,000 acre-feet of long term storage is 820 cubic feet per second. As stated previously in Section III, this yield is based on the assumption that releases for low flow regulation and excess water would be made from the Pepacton Reservoir in the same proportion to the total releases required from all three of New York City's Delaware River reservoirs, that Pepacton's estimated safe yield is to the combined safe yields of the three reservoirs operated by New York City. The final scheme for operation of the Hawk Mountain powerplant would maintain 300 cubic feet per second minimum release from the powerplant at all times. The assumed operation would provide an augmented flow in the river on Saturday and Sunday equivalent to the gross minimum yield of 820 cubic feet per second. Peaking power would be generated 35 hours a week (about a 20 percent weekly load factor) with the remaining water available. This flow available for peaking would be 435 cubic feet per second continuous or 2100 cubic feet per second for peak operation. The extremes of flow from this type operation would be between 300 cubic feet per second minimum to 2100 cubic feet per second maximum (when reservoir less than full) which represents difference in river stages just downstream from the site of about 2.8 feet. This method of powerplant operation eliminates the need for costly reregulating facilities. Normal tailwater at the powerplant would be at elevation 934. The maximum head with full reservoir would be 148 feet, minimum head 74 feet and average long term head of 136 feet. Dependable capacity, based on the minimum head of 74 feet would be 11,000 kilowatts. Installed capacity based

on a wheel capacity of 2100 cubic feet per second and average head of 136 feet would be 21,000 kilowatts.

106. Intake Facilities. Construction of an earth fill dam at Hawk Mountain site would require the use of two 18 foot conduits for diversion during the construction period. These conduits with the appurtenant intake facilities would be available for later use as power intakes. The diversion conduits would be constructed in a trench excavated on the left side of the site. They would have a total length of about 800 feet from the intake structure to their point of discharge below the dam and would have a level grade throughout their length. A discharge channel would be constructed below the lower end of these conduits.

107. Power Penstocks. The powerplant would require two 10,500 kilowatt units. Each unit would require a steel penstock with a 13-foot inside diameter. Each of the diversion conduits described above would be plugged at the axis of the dam, and 13-foot diameter steel penstocks installed on cradles inside its lower section. The steel sections would have an average length of 420 feet from the concrete plug to the entrance to the powerhouse. From considerations similar to those for Tocks Island site as discussed in paragraph 94, a decision was made for Hawk Mountain project to omit surge tanks in this survey on the basis that the velocity in the penstocks will not exceed 10 feet per second.

108. Powerplant. The powerplant would be located on the left bank of the river with its major axis approximately at right angles to the river channel. The center of the plant would be about 450 feet below the axis of the dam. It would be constructed in the diversion channel with foundations to solid rock, assumed to be at elevation 910 feet. More extensive pre-construction foundation explorations may later result in this elevation being raised or lowered. Two Francis-type turbines, each with a rating at best head of 15,000 horsepower would be installed in this plant. These units would each be direct-connected to a 10,500 kilowatt generator.

a. Substructure. The substructure of the powerplant would be constructed of massive concrete, with steel reinforcing placed around various openings as required. It would consist of two main bays, each of which would contain a 15,000 horsepower unit, complete with turbine and scroll case. A service bay of the same size as the main bays would be constructed on the abutment side of the powerplant for use in maintenance and repair of the units. Each of these bays would be 50 feet wide and 30 feet long. The top of the substructure would be at elevation 960 feet and would form the generator floor of the powerplant. Each of the two units in the substructure would have a 4 X 3 foot bypass for use when the units were undergoing maintenance or repair.

b. Superstructure. A reinforced concrete superstructure would be constructed over the three powerplant bays. It would have a clear height of 35 feet over all three main bays to permit the installation and operation of an overhead traveling crane required for installation and maintenance of the power units.

c. Tailrace. The diversion channel used during the construction period would be constructed to necessary dimensions to provide a tailrace for the powerplant.

109. Powerplant Access Road. An access road would be constructed at elevation 960 feet on the downstream slope of Hawk Mountain dam to connect the powerplant with U. S. Highway No. 17. It would extend about 700 feet along the dam, about 1000 feet along the right bank of the river on an abandoned railroad grade, and about 1,600 feet up a ravine to intersect with relocated U. S. Highway No. 17. The paving would be heavy-duty type designed to transport the largest pieces of powerplant equipment.

110. Switchyard and Transformers. The step-up substation would be located adjacent to the powerhouse on a raised section of the toe of the main embankment. The substation would be of the outdoor type consisting of one 110 kv., three-phase transformer with associated switching and protective equipment. One transformer, rated at 25,000 kv.-a. would be required for the 21,000-kilowatt installation at Hawk Mountain.

111. Cost of Project. Survey-type designs and cost estimates were made for the power installation at Hawk Mountain site. The general features of these designs, as described above, are shown on Plate T-9. Cost estimates are shown in Appendix U, Project Design and Cost Estimate. A summary of these estimates, including allowances for contingencies, engineering, design and administration is as follows:

POWER FACILITIES - HAWK MOUNTAIN

Penstock	$ 845,000
Powerplant	3,714,000
Tailrace	231,000
Access Road	57,000
Switchyard	232,000
Total	$5,079,000

Table T-27 summarizes the specific power costs and benefits and shows a net annual benefit from this power installation of $248,000.

X SUMMARY

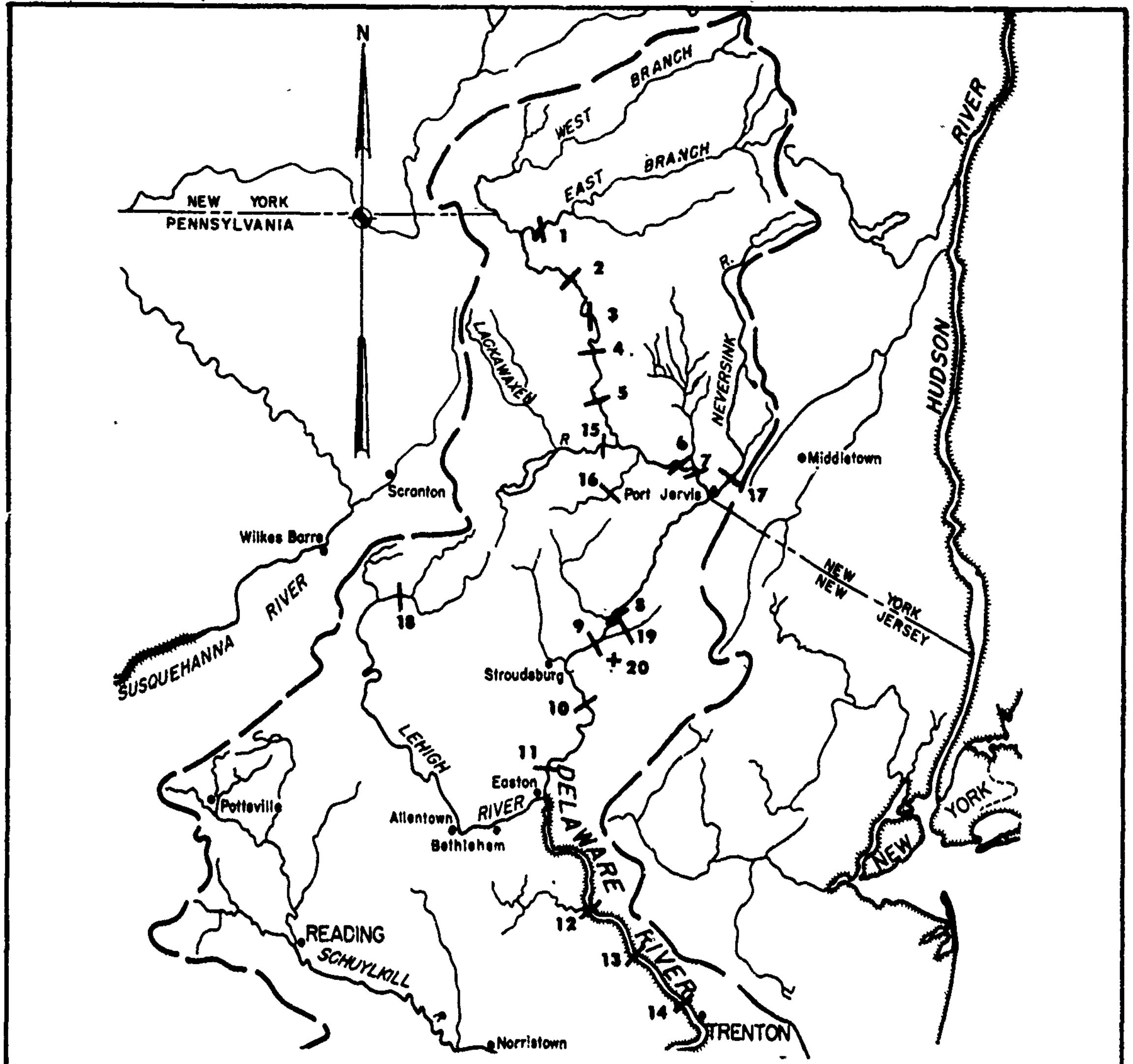
112. The installation of hydroelectric power facilities to utilize water provided by multiple purpose development at the Tocks Island and Hawk Mountain sites, is economically feasible based on specific power costs.

113. The conventional hydroelectric powerplant at Tocks Island site would have an installed capacity of 46,000 kilowatts, a dependable capacity of 20,000 kilowatts and would produce 281,5 million kilowatt-hours of average annual energy. The total investment for this installation based on specific power costs, would be $12,925,000, and have average annual charges of $1,038,000. Average annual benefits were estimated at $1,825,000. The pumped storage powerplant at Tocks Island site would have an installed capacity of 366,000 kilowatts. The total investment for this installation based on specific power costs would be $56,541,000, and have average annual charges of about $8,568,400. Average annual benefits were estimated at $11,046,000.

114. The hydroelectric powerplant at Hawk Mountain site would have an installed capacity of 21,000 kilowatts, a dependable capacity of 11,000 kilowatts and would produce 93.8 million kilowatt-hours of average annual energy. The total investment for this installation, based on specific power costs, would be $5,321,000, and have average annual charges of $507,000. Average annual benefits were estimated at $755,000.

115. Investigation of the pumped storage power potential, as made by the Power Work Group, indicates that hydroelectric power is economically feasible as proposed by the New Jersey Power and Light Company at the Yards Creek site. The proposed installation at Yards Creek would be 150,000 kilowatts, and the average annual production would be about 265 million kilowatt-hours. The cost of this project was estimated in 1956 at about $167.60 per kilowatt of installed capacity.

CORPS OF ENGINEERS U.S. ARMY



POWER SITES INVESTIGATED

No.	Power Site	Stream
1	Hawk Mountain	E. Br. Delaware R.
2	Hankins	Delaware River
3	Callicoon	Delaware River
4	Skinners Falls	Delaware River
5	Tusten	Delaware River
6	Knights Eddy	Delaware River
7	Hawks Nest	Delaware River
8	Wallpack Bend	Delaware River
9	Tocks Island	Delaware River
10	Belvidere	Delaware River
11	Chestnut Hill	Delaware River
12	Holland	Delaware River
13	Eagle Island	Delaware River
14	Goat Hill	Delaware River
15	Lackawaxen	Lackawaxen R.
16	Shohola Falls	Shohola Creek
17	Basher Kill	Neversink River
18	Tobyhanna	Lehigh River
19	Flat Brook	Flat Brook
20	Yards Creek	Yards Cr.

SCALE OF MILES
8 0 8 16 24 32 40

REVIEW REPORT
DELAWARE RIVER BASIN
LOCATION-POWER SITES INVESTIGATED

U.S ENGINEER DISTRICT PHILA.
DRAWER NO. 228 FILE NO. 29137

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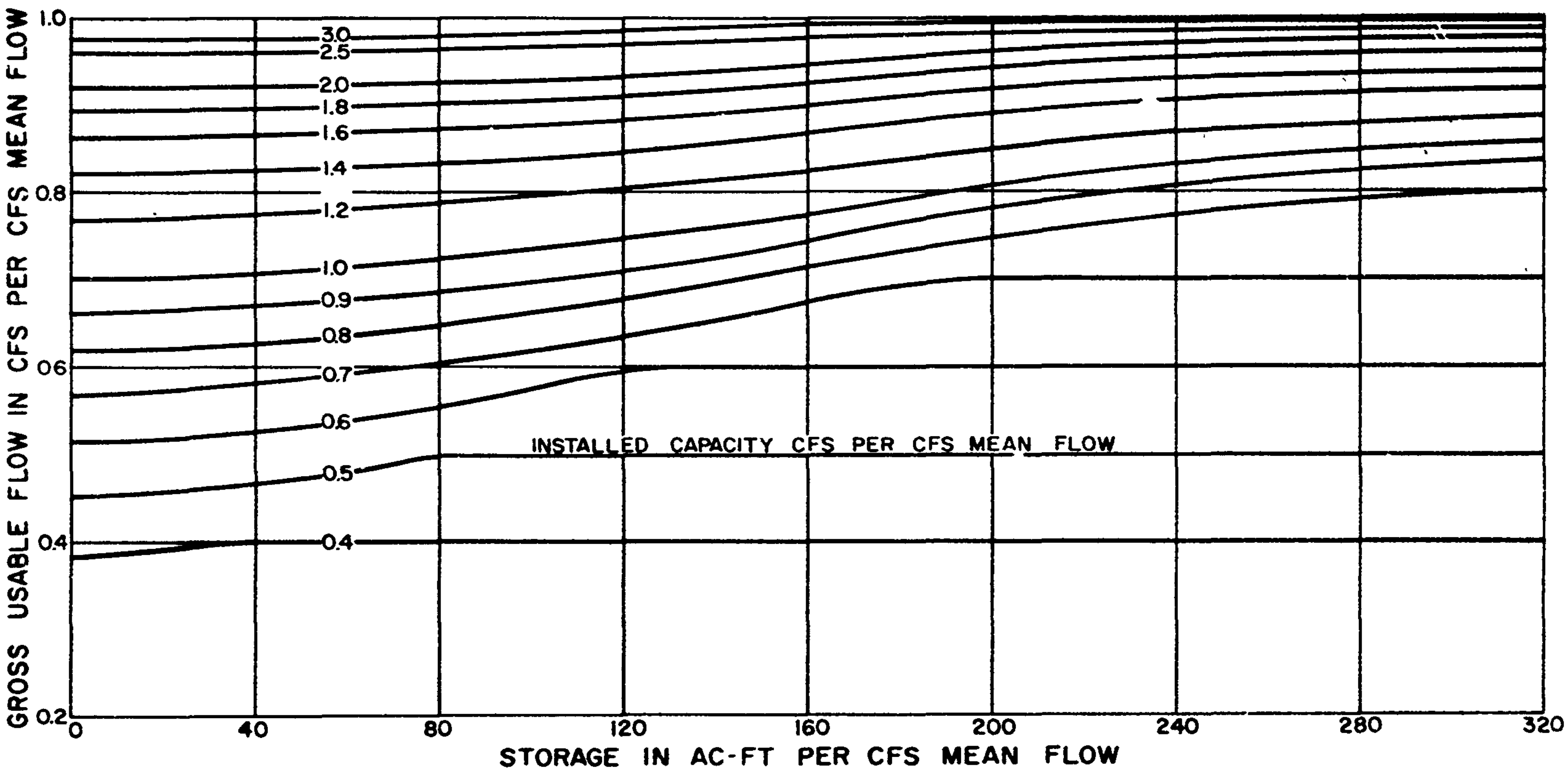


NOTES:

Record used - adjusted flows - Delaware River at Tocks Island, 1923-1957.

Flows estimated from Montague record and local streams with Montague flows adjusted for upstream regulation.

REVIEW REPORT

DELAWARE RIVER BASIN

AVERAGE ANNUAL USABLE FLOW

DELAWARE RIVER

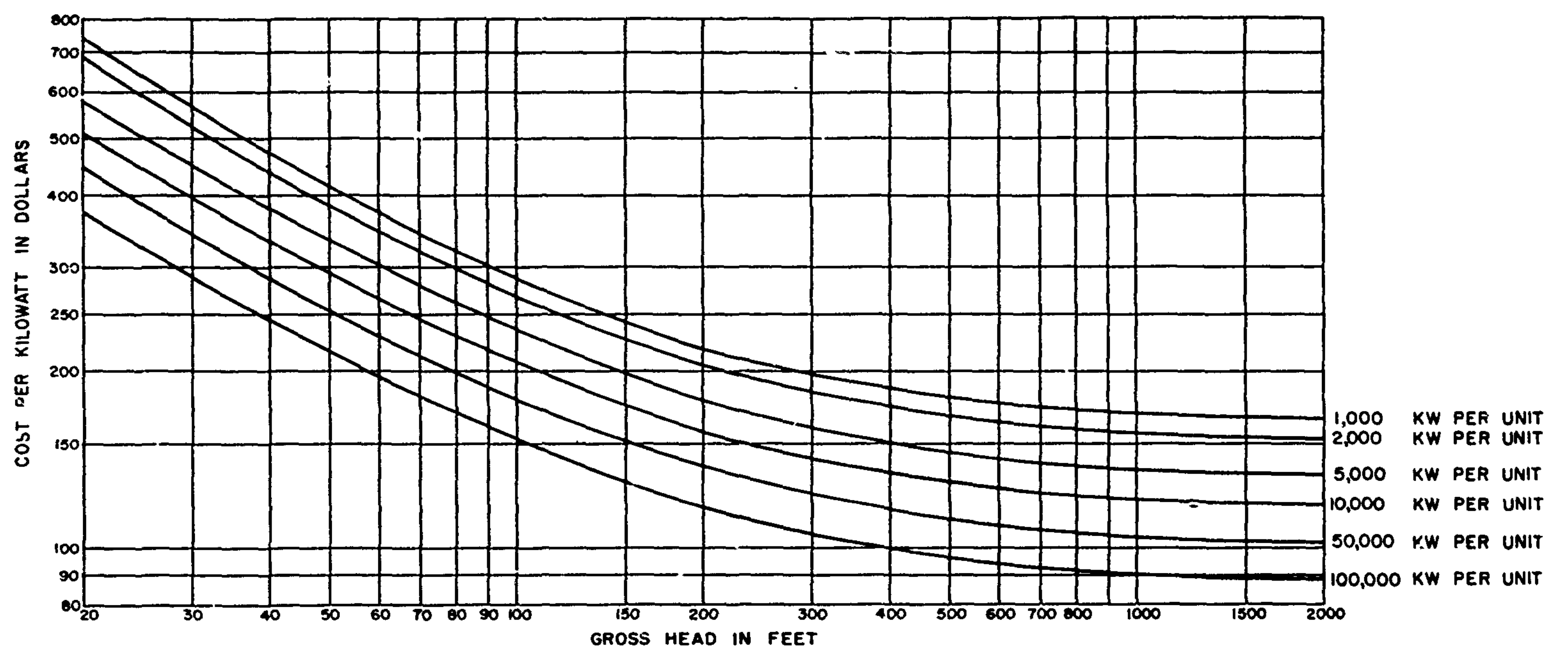
U.S. ENGINEER DISTRICT PHILA.

DRAWER NO. 228 FILE NO. 29138

PLATE T-2

CORPS OF ENGINEERS

U.S. ARMY



NOTES·

Curves include the cost of "structures and improvements" and "equipment." The former includes the costs of powerplant building and yard improvements, and the latter includes the cost of turbines and generators, accessory low tension equipment, and miscellaneous powerplant equipment.

Overhead costs at 18% are included, but cost of land, step-up substation, and intake facilities are not included.

Curves were derived from cost estimates made by Federal Power Commission as of 1 January 1949, by applying an escalation factor of 1.5 to obtain 1 October 1957 estimated costs.

REVIEW REPORT
DELAWARE RIVER BASIN
ESTIMATED AVERAGE COST
HYDROELECTRIC POWERPLANTS

U.S. ENGINEER DISTRICT PHILA.
DRAWER NO. 228 FILE NO. 29139

CORPS OF ENGINEERS

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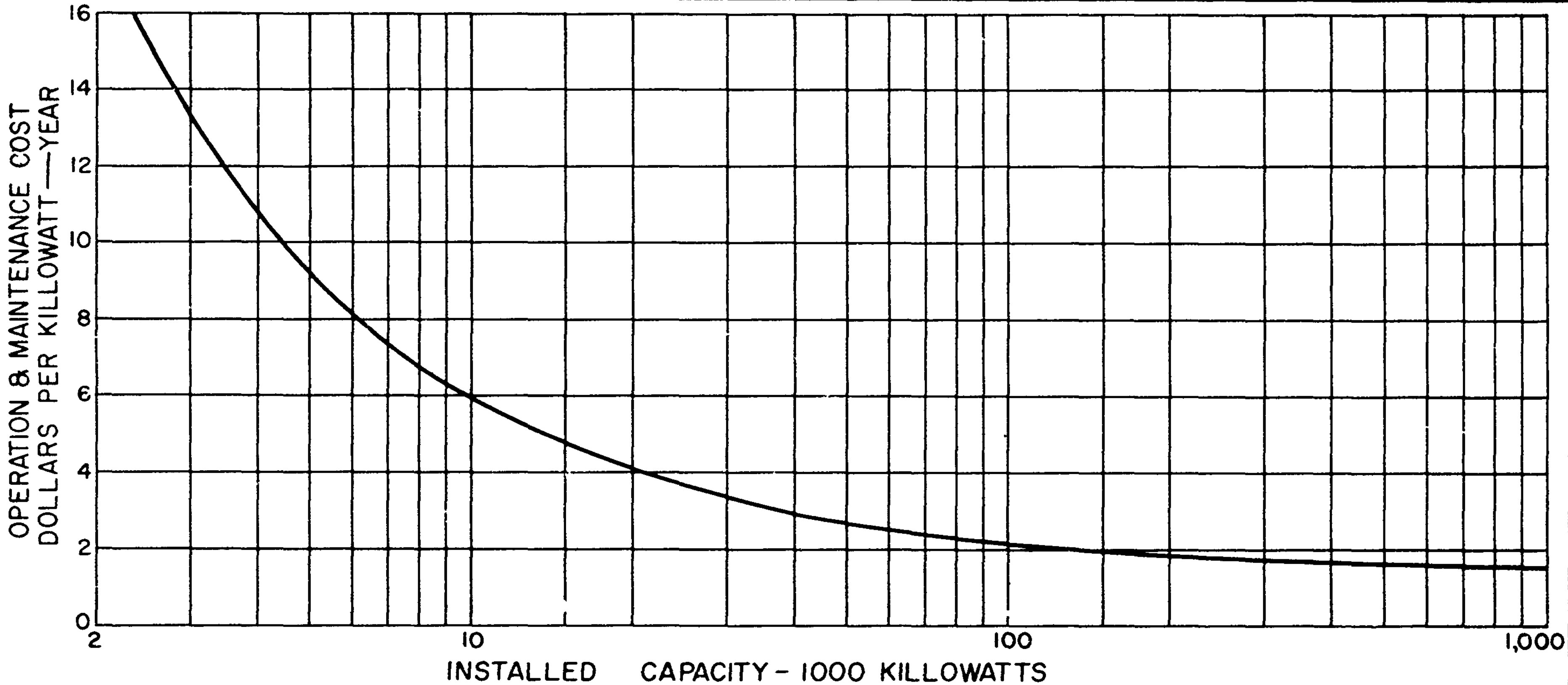
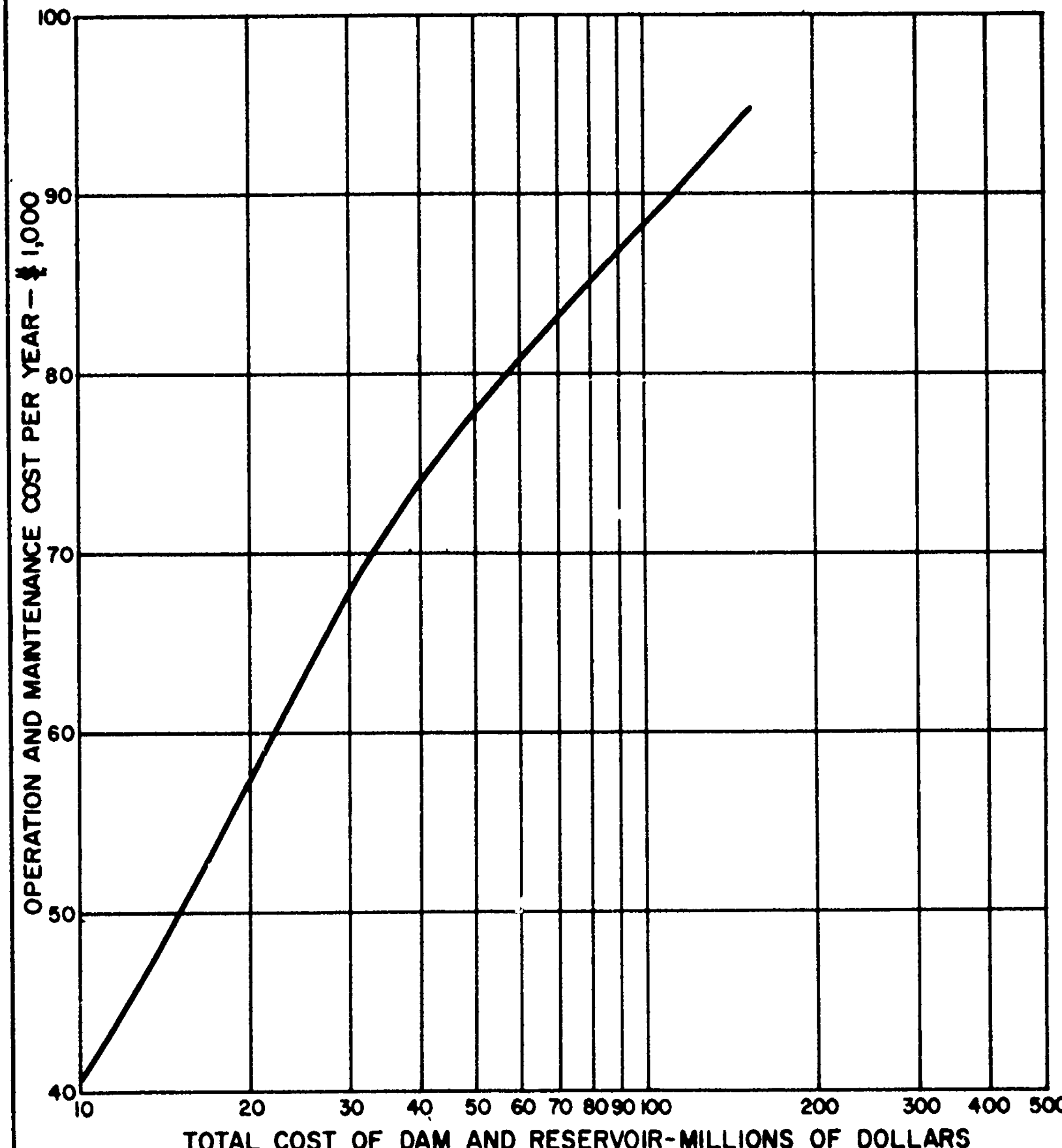


NOTE.
Data taken from Technical Memorandum No. 1 prepared by Federal Power Commission as revised May 1958

REVIEW REPORT
DELAWARE RIVER BASIN
ANNUAL O&M COSTS
HYDROELECTRIC POWERPLANTS

U.S. ENGINEER DISTRICT PHILA.
DRAWER NO. 228 FILE NO. 29140

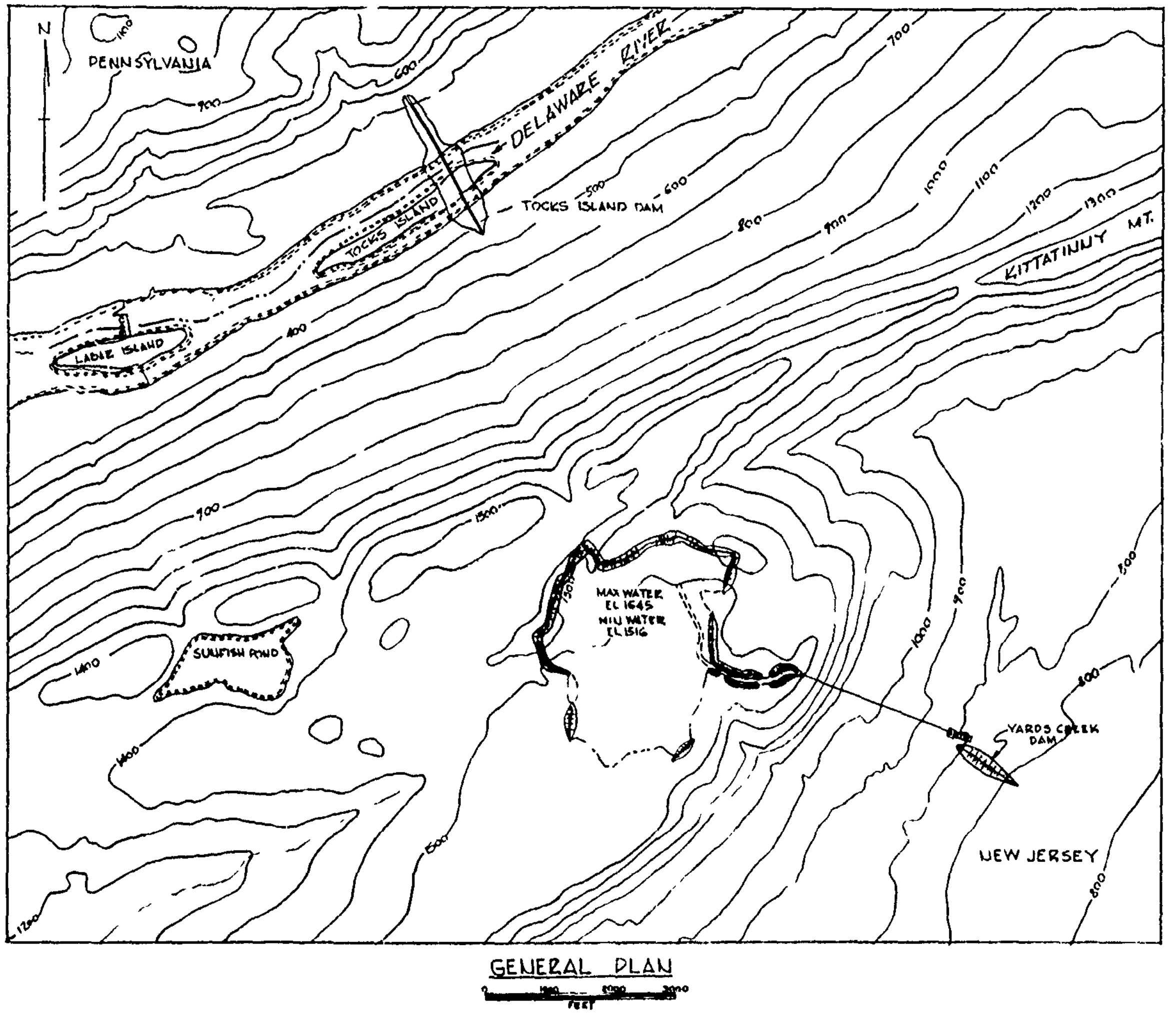


NOTE:
Data from annual report of the Chief of Engineers, U.S. Army - 1956

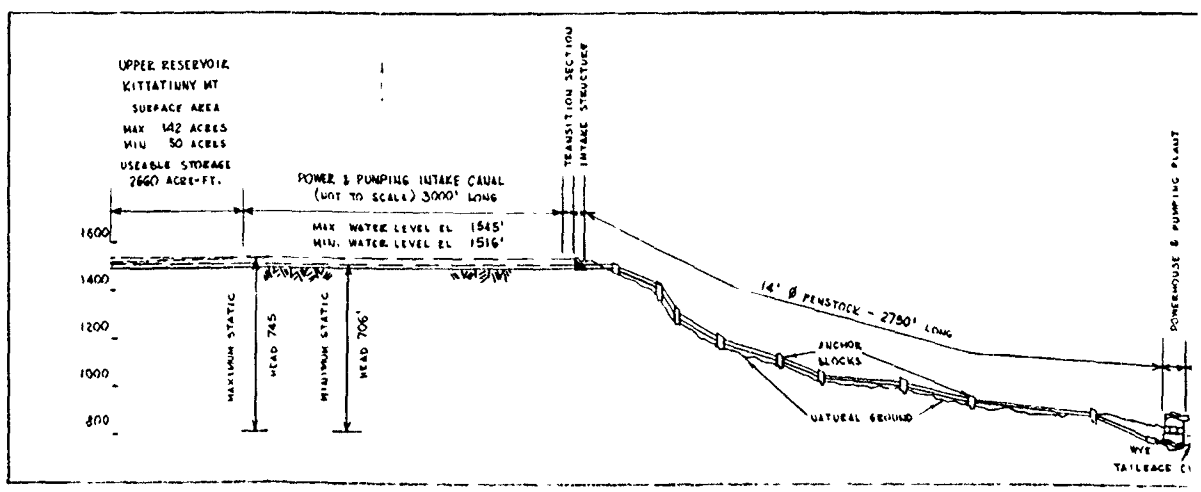
REVIEW REPORT
DELAWARE RIVER BASIN
DAM AND RESERVOIR
OPERATION & MAINTENANCE COSTS

U.S. ENGINEER DISTRICT PHILA.
DRAWER NO. 228 FILE NO. 29141

CORPS OF ENGINEERS

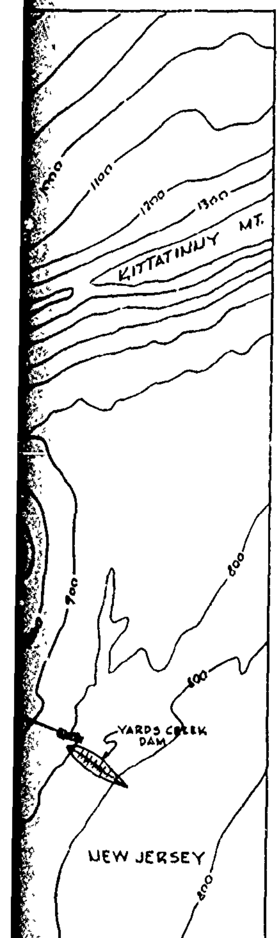


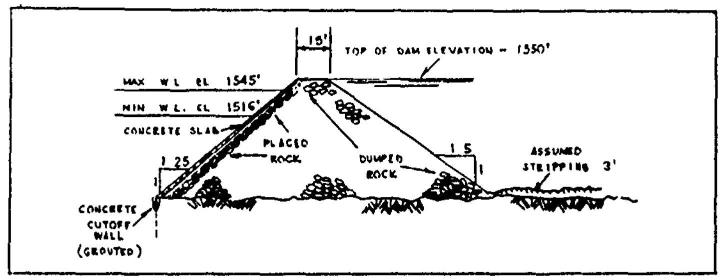
GENERAL PLAN



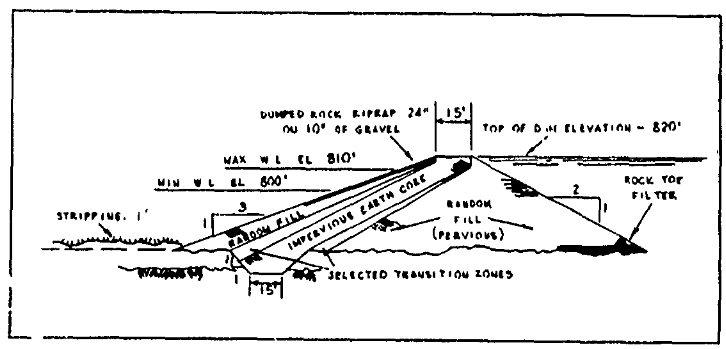
PROFILE ALONG POWER AND PUMP FLOW LINE

U. S. ARMY



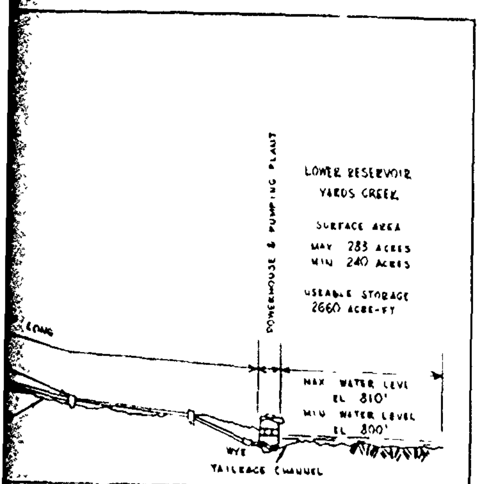


TYPICAL SECTION THRU UPPER DAMS



TYPICAL SECTION THRU LOWER DAM

NOTE
Data provided by New Jersey Power & Light Company, for use of Power Work Group.

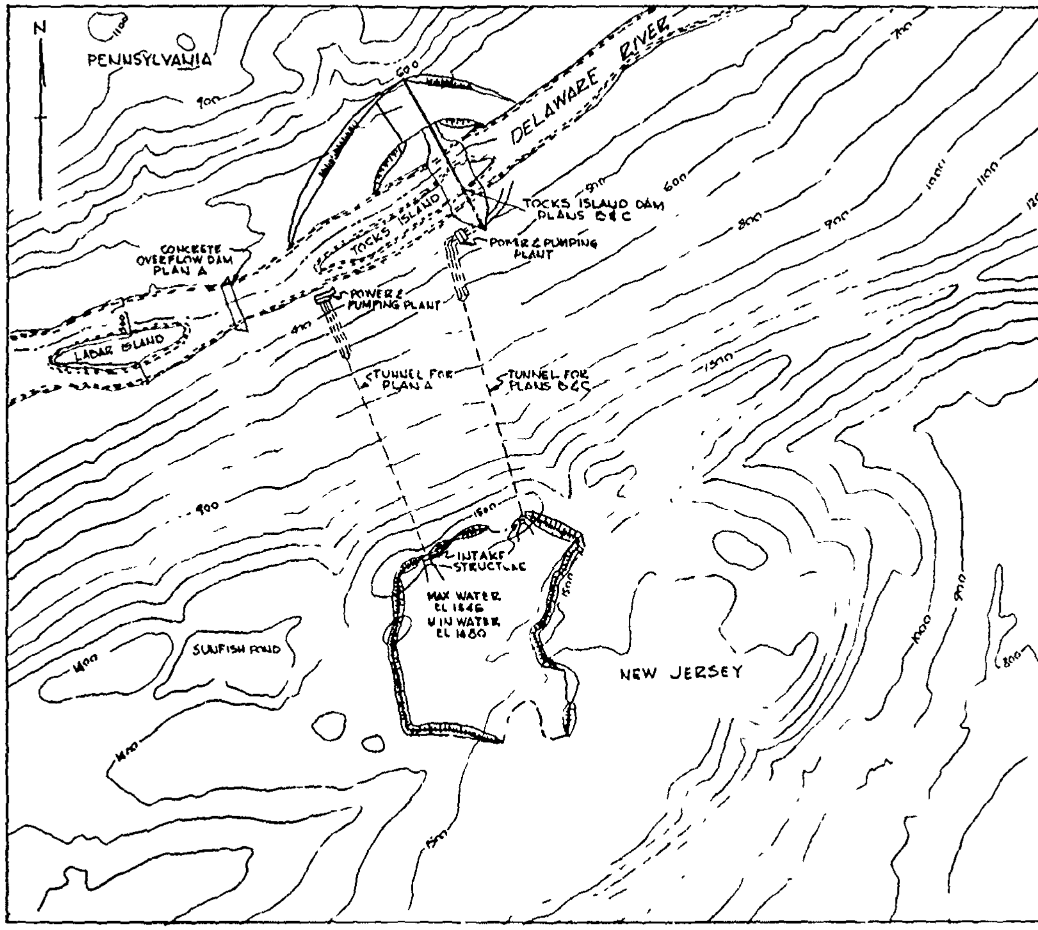


REVIEW REPORT
DELAWARE RIVER BASIN

KITTATINNY MT. - YARDS CREEK
PUMPED STORAGE PROJECT

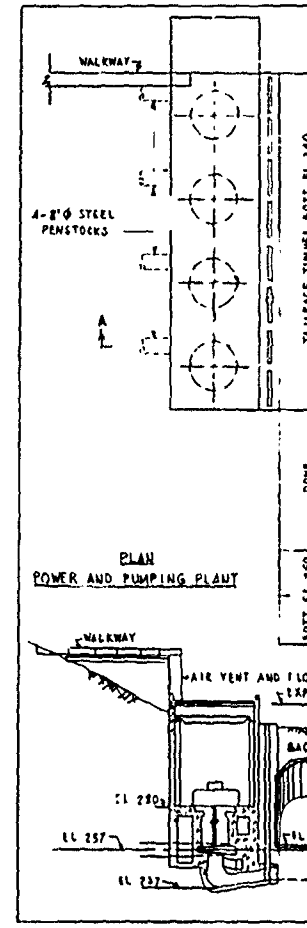
U.S. ENGINEER DISTRICT PHILA.
DRAWER NO 228 FILE NO. 29143

CORPS OF ENGINEERS



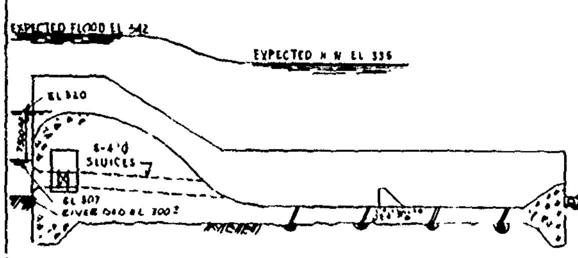
LOCATION MAP

0 1000 2000 3000 FEET



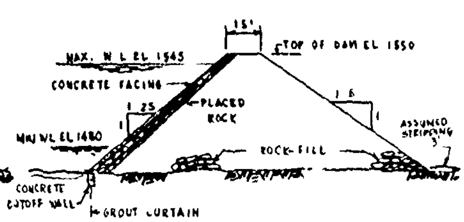
POWER PLANT - P

0 20 40 60 FEET



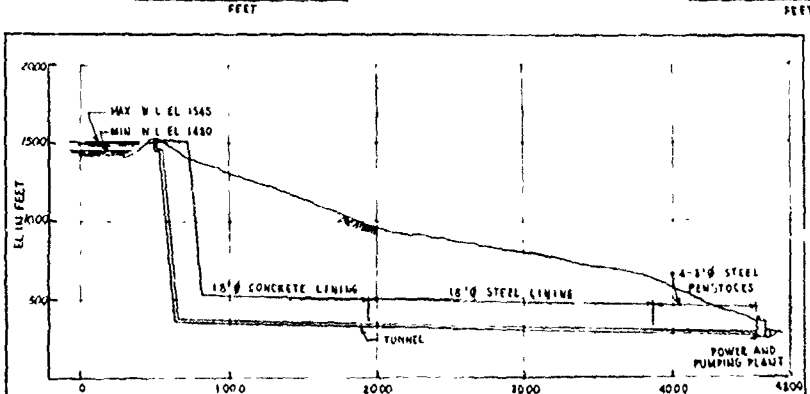
SECTION THRU LOWER RESERVOIR SPILLWAY

0 10 20 30 40 50 60 FEET



TYPICAL SECTION THRU UPPER RESERVOIR DIKES

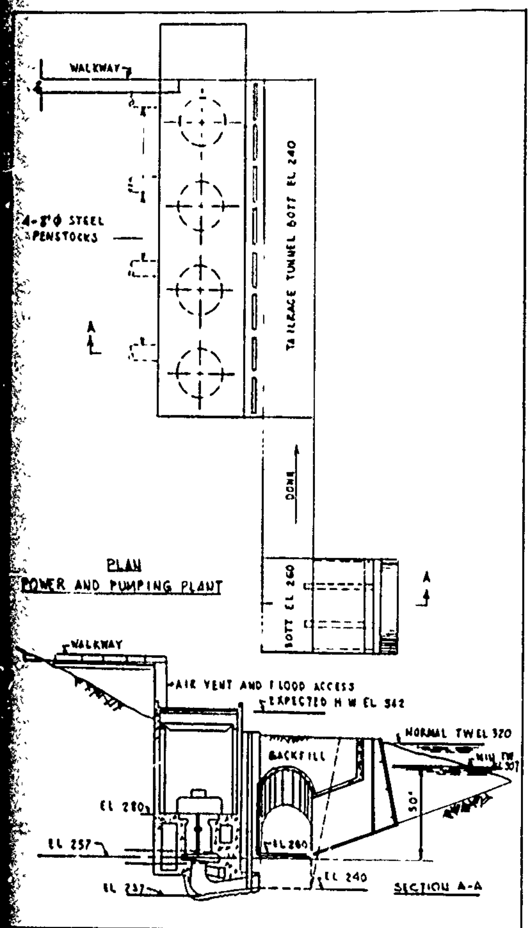
0 25 50 100 FEET



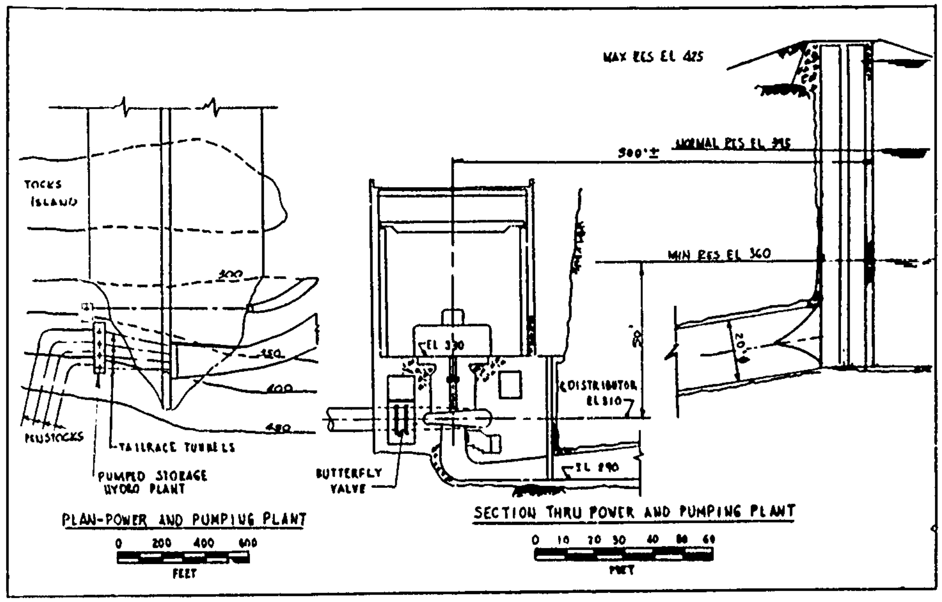
PROFILE ALONG POWER AND PUMP FLOW LINE

NOTE:
Data p
Compa

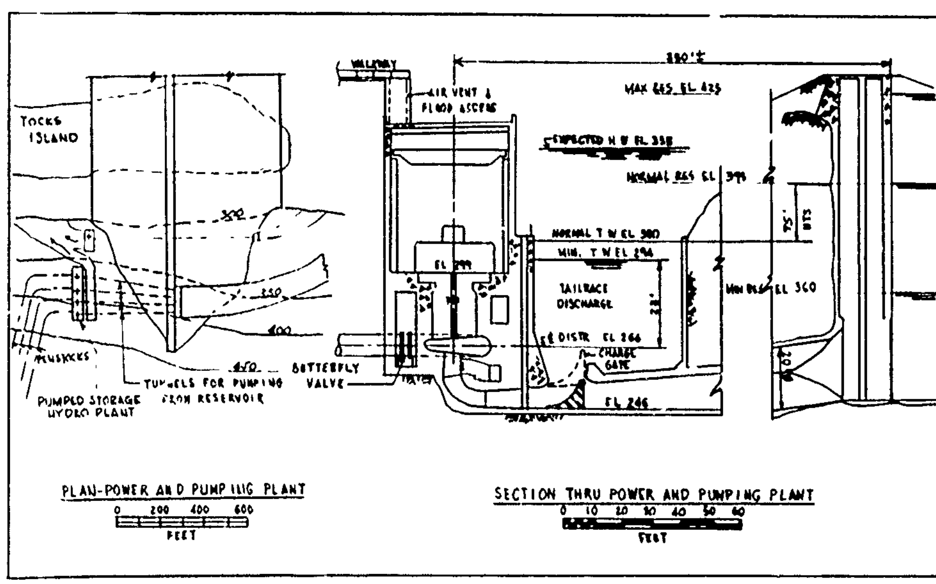
U. S. ARMY



POWER PLANT - PLAN A



POWER AND PUMPING PLANT - PLAN B



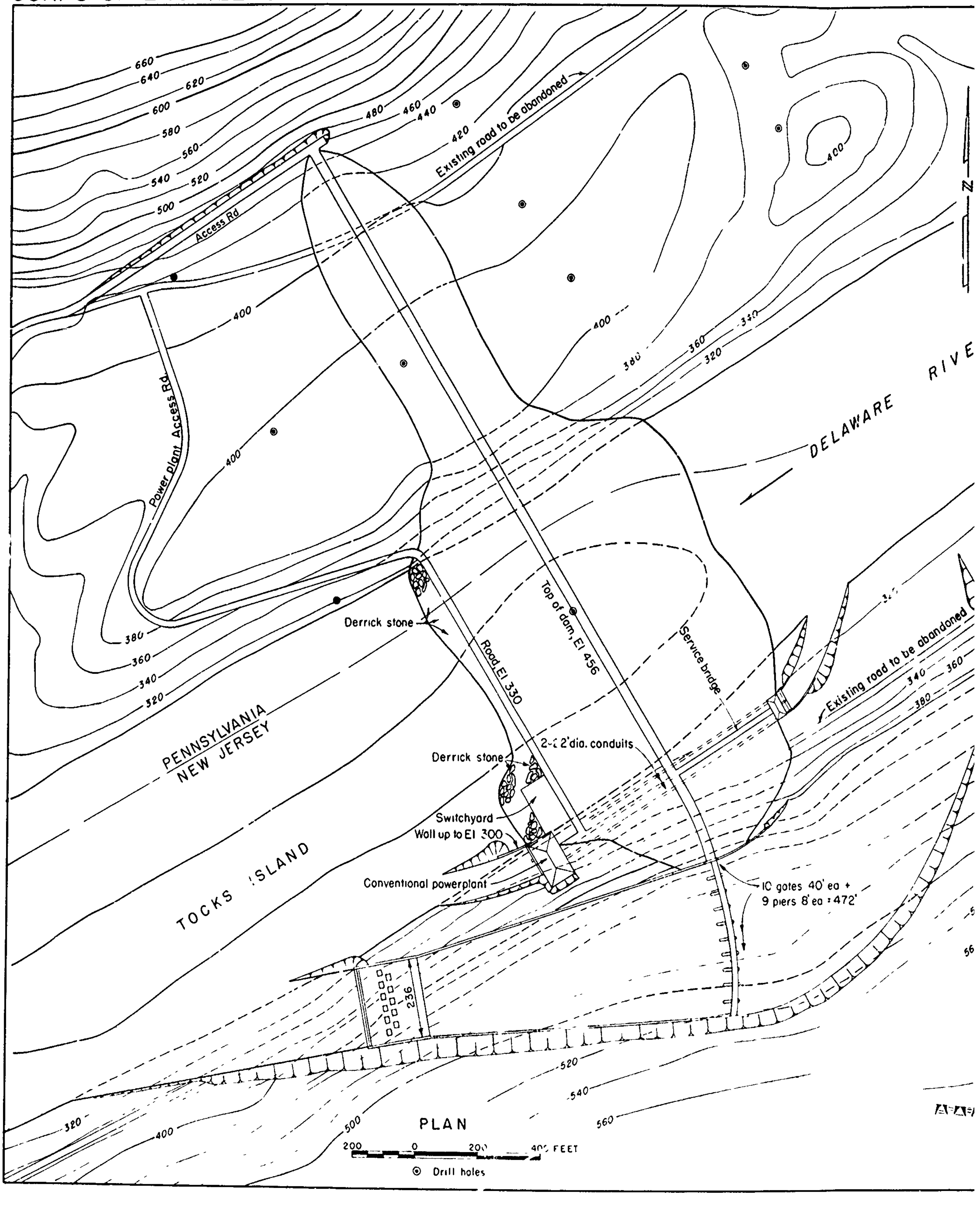
POWER AND PUMPING PLANT - PLAN C

NOTE:
Data provided by New Jersey Power & Light Company for use of Power Work Group.

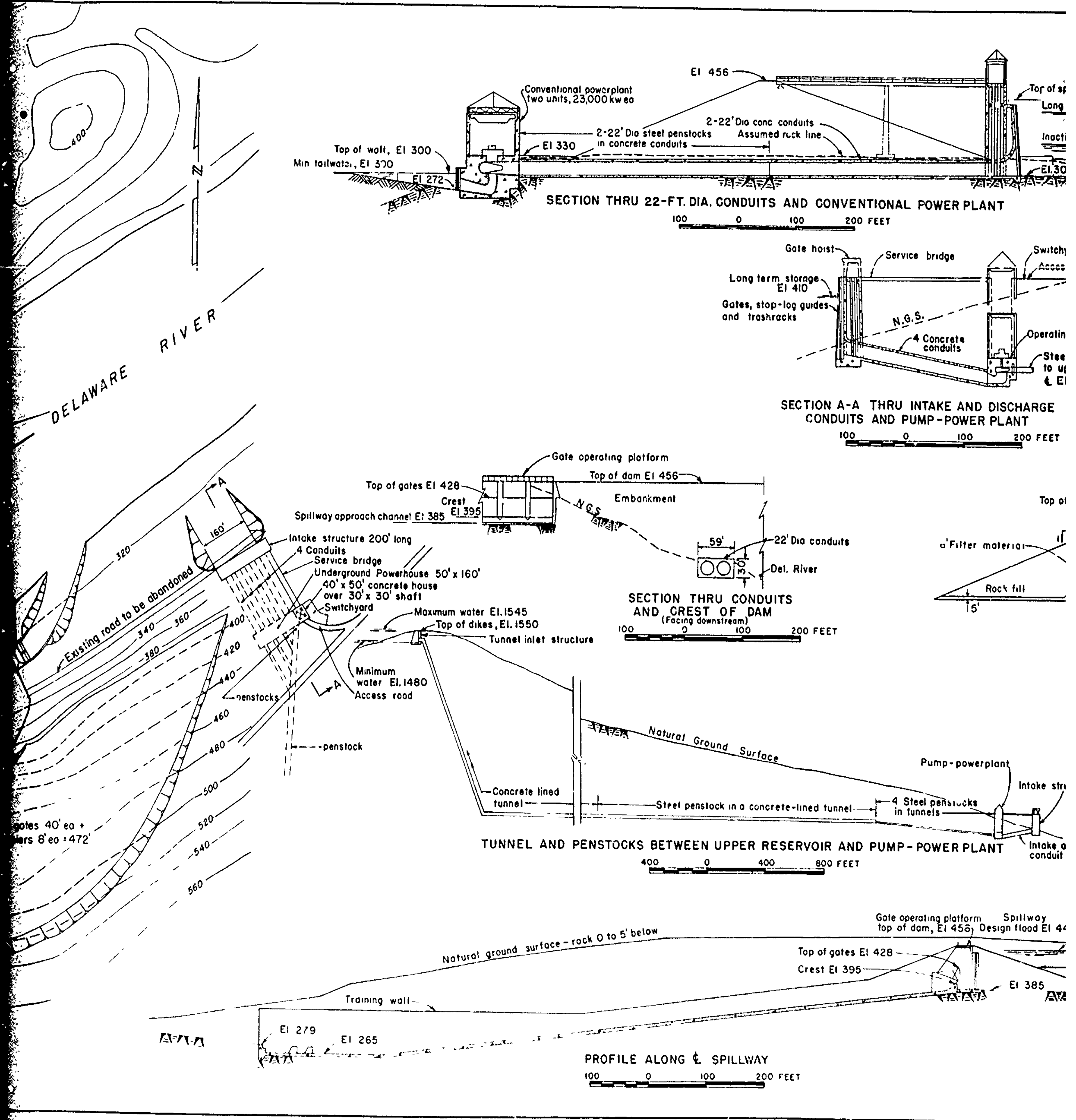
REVIEW REPORT
DELAWARE RIVER BASIN

KITTATINNY MT. - TOCKS ISLAND
PUMPED STORAGE PROJECT

U S ENGINEER DISTRICT PHILA.
DRAWER NO 228 FILE NO. 29142

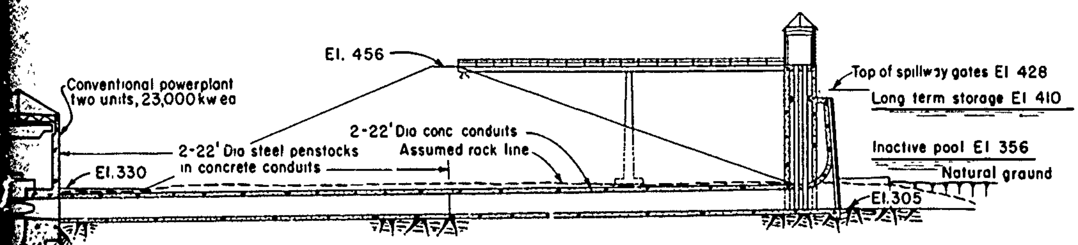


660
640
620
600
580
560
540
520
500
480
460
440
420
400
380
360
340
320
Existing road to be abandoned
Access Rd
Power plant Access Rd
DELAWARE
RIVE
Derrick stone
Road El 330
Top of dam, El 456
Service bridge
PENNSYLVANIA
NEW JERSEY
TOCKS ISLAND
Switchyard
Wall up to El 300
Conventional powerplant
10 gates 40' ea +
9 piers 8' ea = 472'
236
520
540
560
500
PLAN
FEET
Drill holes



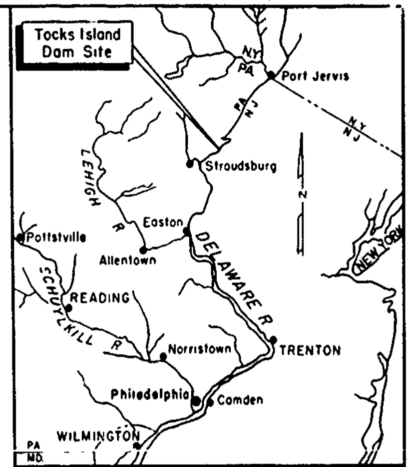
DELAWARE RIVER
N
400
320
340
360
380
420
440
460
480
500
520
540
560
Existing road to be abandoned
160'
Intake structure 200' long
4 Conduits
Service bridge
Underground Powerhouse 50' x 160'
40' x 50' concrete house over 30' x 30' shaft
Switchyard
penstocks
penstock
Access road
gates 40' ea +
ers 8' ea = 472'
El 456
Conventional powerplant two units, 23,000 kw ea
2-22' Dia steel penstocks in concrete conduits
2-22' Dia conc conduits
Assumed rock line
Top of wall, El 300
Min tailwater, El 300
El 330
El 272
SECTION THRU 22-FT. DIA. CONDUITS AND CONVENTIONAL POWER PLANT
100 0 100 200 FEET
Gate hoist
Service bridge
Long term storage El 410
Gates, stop-log guides and trashracks
N.G.S.
4 Concrete conduits
SECTION A-A THRU INTAKE AND DISCHARGE CONDUITS AND PUMP-POWER PLANT
100 0 100 200 FEET
Gate operating platform
Top of dam El 456
Top of gates El 428
Crest El 395
Spillway approach channel El 385
Embankment
N.G.S.
59'
30'
22' Dia conduits
Del. River
SECTION THRU CONDUITS AND CREST OF DAM
(Facing downstream)
100 0 100 200 FEET
Rock fill
5'
Maximum water El. 1545
Top of dikes, El. 1550
Tunnel inlet structure
Minimum water El. 1480
Natural Ground Surface
Pump-powerplant
Concrete lined tunnel
Steel penstock in a concrete-lined tunnel
4 Steel penstocks in tunnels
TUNNEL AND PENSTOCKS BETWEEN UPPER RESERVOIR AND PUMP-POWER PLANT
400 0 400 800 FEET
Gate operating platform top of dam, El 456
Spillway
Natural ground surface - rock 0 to 5' below
Top of gates El 428
Crest El 395
El 385
Training wall
El 279
El 265
PROFILE ALONG ℄ SPILLWAY
100 0 100 200 FEET

U. S. ARMY



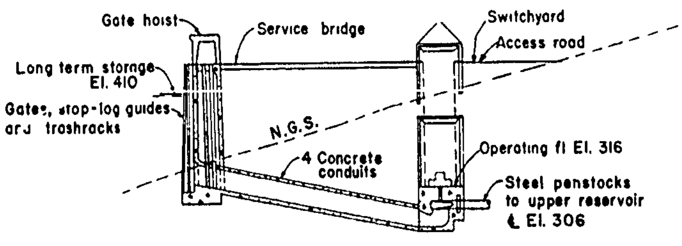
SECTION THRU 22-FT. DIA. CONDUITS AND CONVENTIONAL POWER PLANT

100 0 100 200 FEET



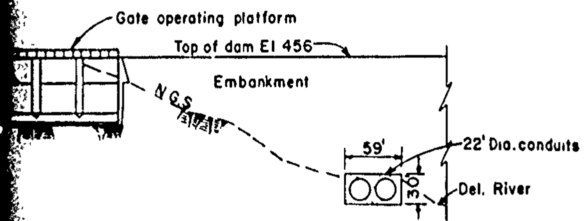
LOCATION MAP

SCALE



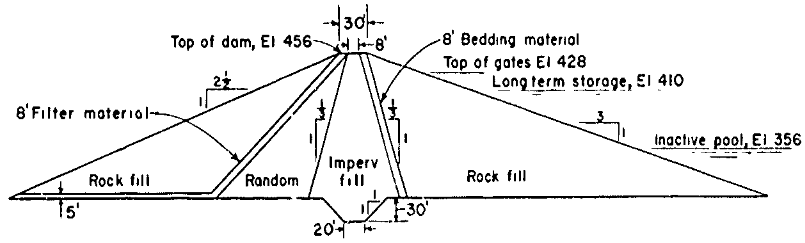
SECTION A-A THRU INTAKE AND DISCHARGE CONDUITS AND PUMP-POWER PLANT

100 0 100 200 FEET



SECTION THRU CONDUITS AND CREST OF DAM
(Facing downstream)

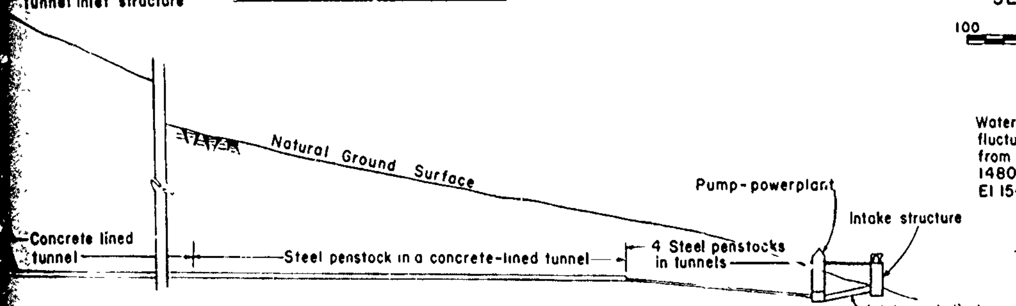
100 0 100 200 FEET



SECTION THRU DAM

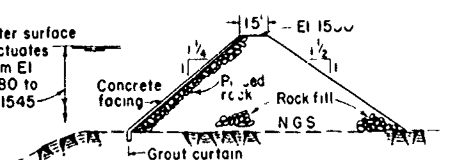
100 0 100 200 FEET

El. 1545
El. 1550
Tunnel inlet structure



TUNNEL AND PENSTOCKS BETWEEN UPPER RESERVOIR AND PUMP-POWER PLANT

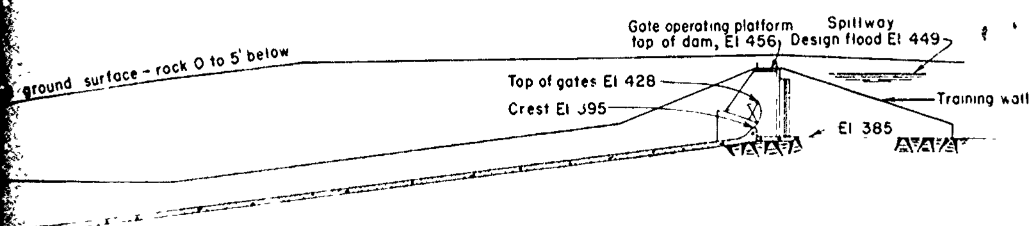
400 0 400 800 FEET



SECTION THRU DIKES AROUND UPPER RESERVOIR

50 0 50 100 FEET

REVIEW REPORT DELAWARE RIVER BASIN



PROFILE ALONG ℄ SPILLWAY

100 0 100 200 FEET

TOCKS ISLAND DAM

In 1 Sheet

Scales as Shown

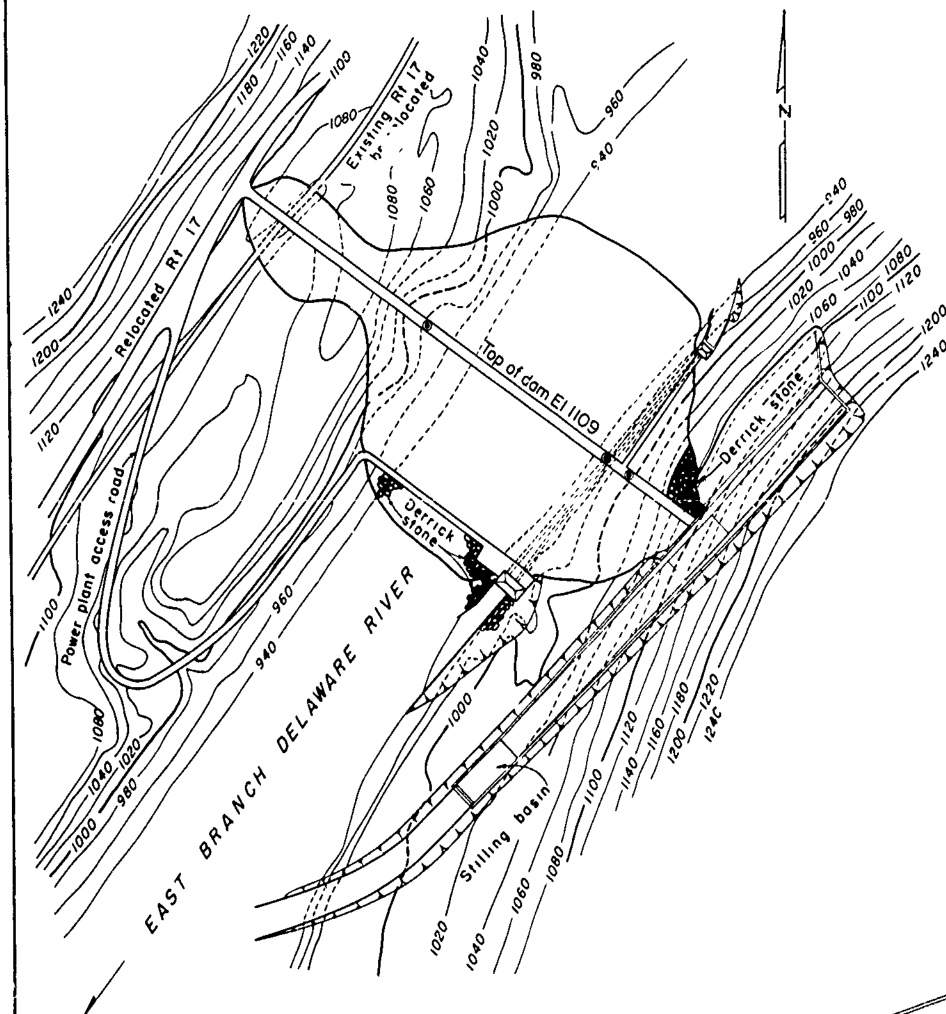
Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960
Revised Oct 1960

Drawer No 228

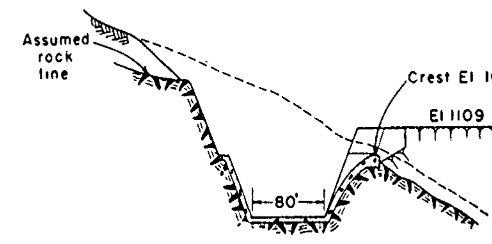
File No 29098

PLATE T-8



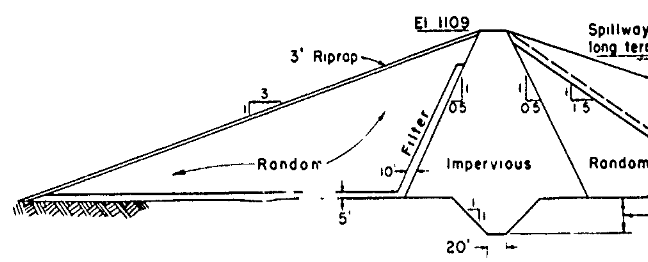
PLAN

200 0 200 400 600 FEET



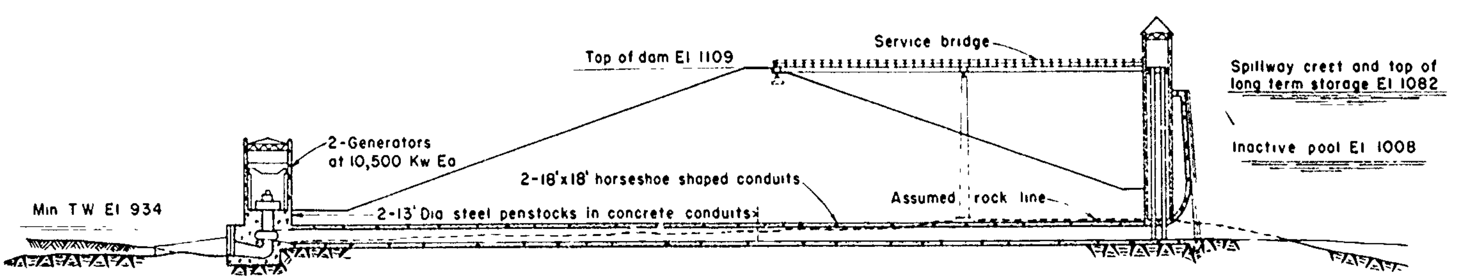
SPILLWAY SECTION

100 0 100 200 FEET



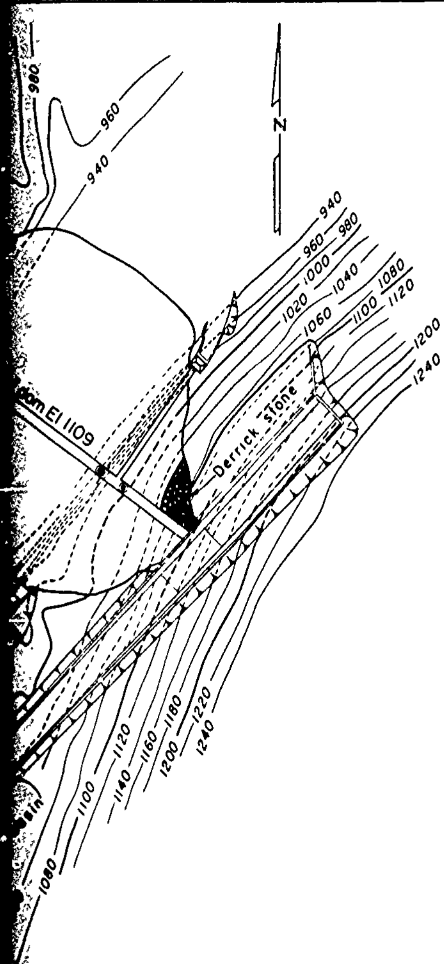
TYPICAL SECTION - DAM

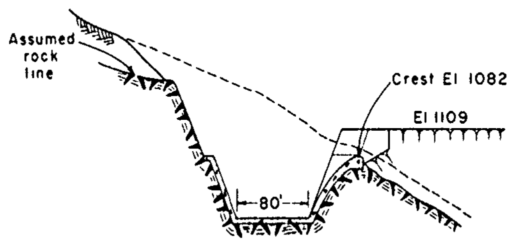
100 0 100 200



SECTION-OUTLET WORKS

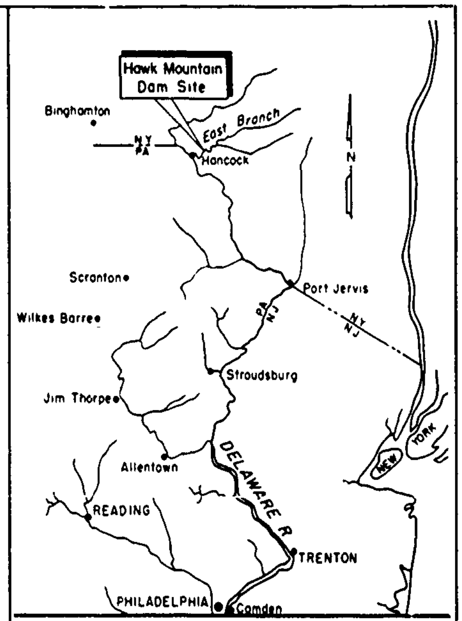
100 0 100 200 300 FEET





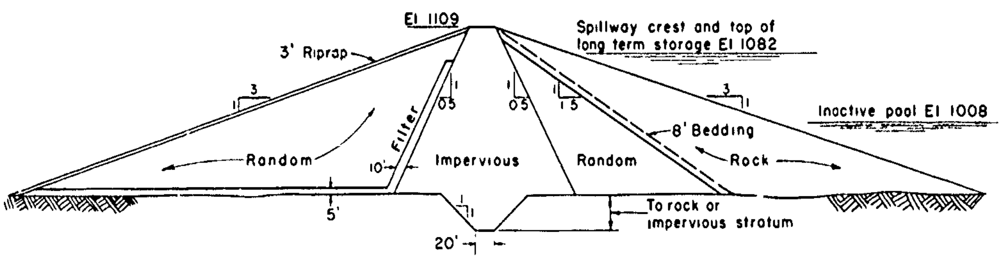
SPILLWAY SECTION

100 0 100 200 FEET



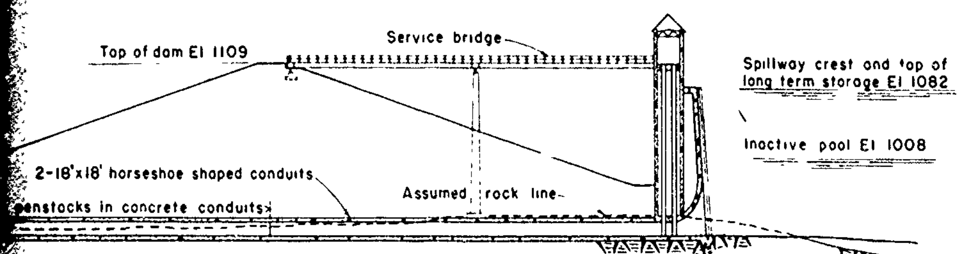
LOCATION MAP

SCALE



TYPICAL SECTION - DAM

100 0 100 200 300 FEET



SECTION - OUTLET WORKS

100 0 100 200 300 FEET

REVIEW REPORT DELAWARE RIVER BASIN

HAWK MOUNTAIN PROJECT

In 1 Sheet

Scale as Shown

Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

Drawer No 228

File No 29112

UNITED STATES
DEPARTMENT OF THE INTERIOR
OFFICE OF THE SECRETARY
WASHINGTON 25, D. C.

NOV 1 6 1960

Dear Sir:

This is in reply to your letter of May 20, 1960, addressed to Mr. Mark Abelson, Interior Member of the Delaware Basin Survey Coordinating Committee, Boston, Massachusetts, requesting an estimate of the revenues that may be expected from the sale of hydroelectric power developed at Hawk Mountain and Tocks Island in connection with the development of water resources of the Delaware River Basin.

The information and data found in the "Report on the Comprehensive Study of the Water Resources of the Delaware River Basin" dated August 1960, have been reviewed. In addition, representatives of the Federal Power Commission Regional Office in New York, your office, and this office, met on September 27 in New York to discuss the development of hydroelectric power for these two projects.

Information and studies in the report indicate that a substantial market for the power developed at Hawk Mountain and Tocks Island, including the pumped-storage power scheme at Tocks Island, is available in the immediate area and through the Pennsylvania-New Jersey-Maryland interconnected systems. It is believed that the market can absorb the power proposed to be developed by conventional hydroelectric generation at Hawk Mountain and Tocks Island at the costs indicated in the report.

The development of the pumped-storage scheme at Tocks Island is complex and the experience of this Department in marketing power from pumped-storage development is very limited. However, it appears that the pumped-storage power project in conjunction with the Tocks Island development is economically feasible at the cost indicated.

We appreciate the opportunity to review the report.

Sincerely yours,

Fred G. Aandahl

Assistant Secretary of the Interior

District Engineer
U. S. Army Engineer District
Corps of Engineers
P. O. Box 8629
Philadelphia 1, Pennsylvania

APPENDIX T

EXHIBIT A

REPORT ON THE COMPREHENSIVE SURVEY OF THE WATER RESOURCES OF THE DELAWARE RIVER BASIN

APPENDIX U

PROJECT DESIGNS AND COST ESTIMATES

PREPARED BY
U. S. ARMY ENGINEER DISTRICT, PHILADELPHIA
CORPS OF ENGINEERS
PHILADELPHIA, PA.
JUNE 1960

CONTENTS

TABLES

PLATES

APPENDIX U

PROJECT DESIGNS AND COST ESTIMATES

I BASIS FOR DESIGNS AND ESTIMATES

1. Scope. There are presented in this appendix designs and cost estimates of the physical features for each project proposed as an element of the recommended comprehensive plan for development of water resources of the Delaware River basin. Designs and detailed cost estimates were made using general principles of accepted practice and design practices described in engineering manuals of the Corps of Engineers together with design criteria and basic data described in this appendix.

2. Design Requirements. Basic data and information for such features as spillway design flood, diversion flows, various reservoir levels for storage requirements, downstream water demands, and hydroelectric power facilities, applicable to each reservoir and dam site included in the recommended comprehensive plan of development of water resources in the Delaware River basin have been developed and described in other appendices to this report. A brief restatement of design requirements for ultimate project design follows.

3. Spillway Design Flood. Determination of the spillway design flood was accomplished by applying the spillway design storm runoff to the inflow unit hydrographs at each reservoir site. Discussion of source data and routing procedures is contained in paragraphs 146 to 149, Appendix M. Based on the spillway design flood, the reservoir, and topography of the dam and spillway site, the most economical length for the spillway crest was selected. Pertinent data on spillway design floods and spillway designs for each project are tabulated in table M-29, Appendix M and described in descriptions of each project in this appendix.

4. Freeboard Requirements. Freeboard requirements for each project were based on recent estimates of wind criteria, wave height, and runup values developed in connection with a study of freeboard requirements for the McGee Bend Dam, Texas, plus an allowance for all except concrete dams for frost action. Table M-30, Appendix M, tabulates the pertinent data on freeboard requirements for each project and plate 1 indicates allowances for frost penetration in the basin.

5. Outlet Capacities. Outlet conduits through each of the dams were designed to have sufficient capacity to carry diversion flow during construction, meet release requirements for downstream uses, and drain the short term storage pool in an acceptable time after a flood

occurrence. In those cases where the outlet conduit will also serve as the diversion conduit during construction of the dam, the diversion capacity was provided to safely pass a flood having a recurrence interval of once in approximately eight years. Gates selected for the conduits are large enough to empty the short term storage pool in five days or to release three times the minimum gross yield with the reservoir at conservation pool level. For the power dams, conduits were made large enough to provide for power uses.

6. Reservoir Levels. Reservoir levels were those determined after studies described in Appendix Q. Those levels are given in the description of each project.

7. Reservoir Areas. Reservoir areas to be acquired in fee include all lands at each project below the elevation of the 5-year frequency of filling. In addition, flowage easements would be acquired up to two feet above the level of 5-year-frequency filling or three feet above the spillway, whichever is the higher.

8. Reservoir Clearing. Clearing would be required on all lands in the reservoir areas below the elevation of the 5-year frequency of filling to include removal and burning of trees, brush, fences, and existing buildings; but not to include any grubbing, or removal of stone structures or pavements. Specific areas designated by recreation and fish and wildlife interests would be given a special clearing.

9. Relocation of Roads. Cost estimates for relocated roads have been based on providing improved or new roads to replace those that are so low as to be below the reservoir level or subject to frequent flooding. The estimates include amounts for grading and asphalt surfacing for State or County roads and gravel surfacing for other roads. Reservoir crossings were included where necessary to maintain the continuity of through routes; but new roads or crossings were not estimated in place of existing roads that are routed so as to primarily serve reservoir areas that will be inundated. In accordance with requirements of Public Law 562 a highway crossing over each dam and spillway was considered. However on only one of the 11 major control projects, Maiden Creek, was such a crossing planned. On the other 10 projects a highway, if later certified to be needed, across the dam and spillway, would be structurally feasible and could be built without interference with the proper functioning and operation of the dam. In order to use highways across these dams it would be necessary to construct approach highways to each end of each dam. The access roads, as shown on drawings in this appendix, were planned as narrow gravel-surfaced roads and would require improvements in width, surfacing, grades and alignment to serve as approach highways. Estimated costs for highways over the 10 dams, with approaches are: Aquashicola, $250,000; Bear Creek, $700,000; Beltzville, $730,000; Blue Marsh,

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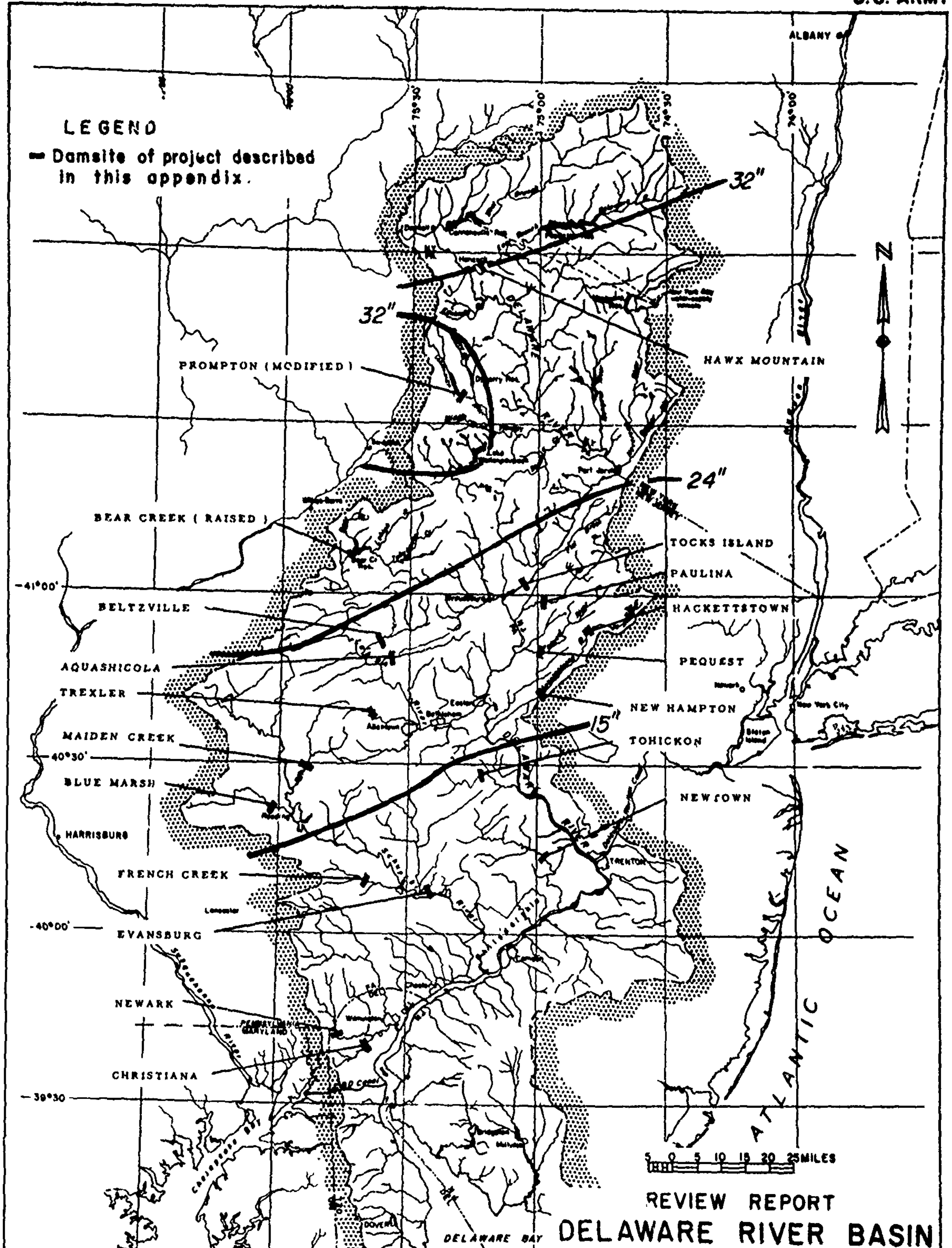

REVIEW REPORT

DELAWARE RIVER BASIN

FROST PENETRATION

NOTE: Frost penetrates to a depth of 12" as far south as the southern boundary of Virginia (170 miles south) on an average of once in 10 years.

In 1 Sheet
Corps of Engineers
Philadelphia, Pa.

Scale as Shown
Philadelphia District
23 Oct. 1959

Drawer No 228

File No. 29344

$840,000; Prompton $580,000; Tocks Island $900,000; Trexler, $500,000; Christiana $580,000; Hawk Mountain, $690,000; and Newark, $430,000. These costs are in addition to those shown in other tables of this appendix.

10. Relocation of Railroads. The estimates include amounts for raising or relocating operating railroad lines that are in proposed reservoir areas. Where relocation would be necessary, routes were selected to maintain grades no steeper than one percent.

11. Relocation of Utilities. Relocation of some transmission lines and pipelines that now cross the various reservoir areas would be required. Relocations would be made to take advantage of narrow crossings of the reservoir or bridges that may be within a reasonable distance of existing lines. Transmission lines which cross only narrow parts of reservoirs would be rebuilt so as to raise them above full-pool reservoir elevations.

12. Recreation. Criteria for determination of land and facilities for development of recreation at each project and detailed cost estimates are given in Appendix W.

13. Power. Studies made of both conventional hydroelectric powerplants and pumped-storage powerplants are described in Appendix T. The designs, on which estimates for the conventional powerplants were made, were based on using the diversion and outlet conduits as power penstocks. At the Tocks Island and Hawk Mountain projects the conduits which are to be used as penstocks for the conventional powerplants are to be lined with steel from the center of the dam to the powerplant. At the Tocks Island project, penstocks from the reservoir to the pump-powerplant will be steel lined downstream from the center of the dam and for about half the distance to the upper reservoir. All powerhouses would rest on rock. The draft tubes and tailrace for the conventional powerplant would be cut into bedrock.

14. Fish and Wildlife. Appendix J to this report entitled "Fish and Wildlife Resources" contains means by which mitigation of losses to existing wildlife habitat, public hunting opportunity, and stream fisheries expected as a result of construction of projects contained herein, may be achieved.

15. Physical Data. The entire Delaware River basin has been mapped by the U. S. Geological Survey and Army Map Service. Topographic maps for the whole basin are available at a scale of 1:62,500. Large parts of the basin are also covered by topographic maps at scales of 1:50,000, 1:31,680, 1:25,000, and 1:24,000. Plate 2 shows names and scales of maps available. In determining reservoir capacities and preparing maps for required relocations, the best published map, (usually the latest map and the one drawn to the largest scale)

was used. Aerial photographs taken by the U. S. Department of Agriculture were used to check field observations and data on the maps pertaining to roads, utilities, improvements and mineral deposits in the reservoir areas. All elevations shown are based on data from the topographic maps or from field surveys which started from USGS benchmarks.

16. Reservoirs. Reservoirs shown on plates in this appendix have been drawn from the best available topographic maps. The extent of roads, railroads and utilities which would require relocation or raising was determined from the reservoir maps. Similarly, routes for relocated roads, railroads and utilities were determined and estimates for such work were based on elevations and distances shown on the same maps.

17. Dam Sites. At each dam site field surveys were made, usually consisting of three to six valley cross sections, using U.S.G.S. benchmarks as a basis for elevations. The field data thus obtained were plotted on enlarged portions of the best available topographic map; and, where necessary, contours, roads, and stream beds were adjusted to agree with the field survey data. These adjusted site maps were used to determine the final alignment and placement of the dam at each selected site and were copied on plates in this appendix.

18. General Geology

a. Introduction. As may be seen on the General Geologic Map, plate 3, the Delaware River basin is divisible into three geologically dissimilar areas, termed the Upper Region, Central Region and Lower Region in this report.

b. The Upper Region. The Upper Region includes the areas shown on the map as underlain by Devonian, Mississippian and Pennsylvanian rocks, the latter two are shown by the symbol "C" (for Carboniferous) on the map. These rocks are mostly flat-lying, usually nonmarine, sandstones, shales and conglomerates of the Pocono and Catskill extensions of the Allegheny Plateau. Anthracite coal occurs in the Carboniferous shales, sandstones and conglomerates, which are strongly folded. Some limestone occurs in the Devonian strata along the southern margin of the region. Except for the extreme southwest corner, the Upper Region was covered by glaciers during the Pleistocene epoch. The ice left much glacial drift (not shown on the map) in the deep valleys and as a thin veneer on the highlands.

c. The Central Region. The Central Region is the most complex region, geologically, in the basin. It extends southward as a series of valleys and ridges, topographically lower than the rocks of the Upper Region, to the rolling hills of the Piedmont and terminates at the Cretaceous coastal-plain sediments of the Lower Region. This

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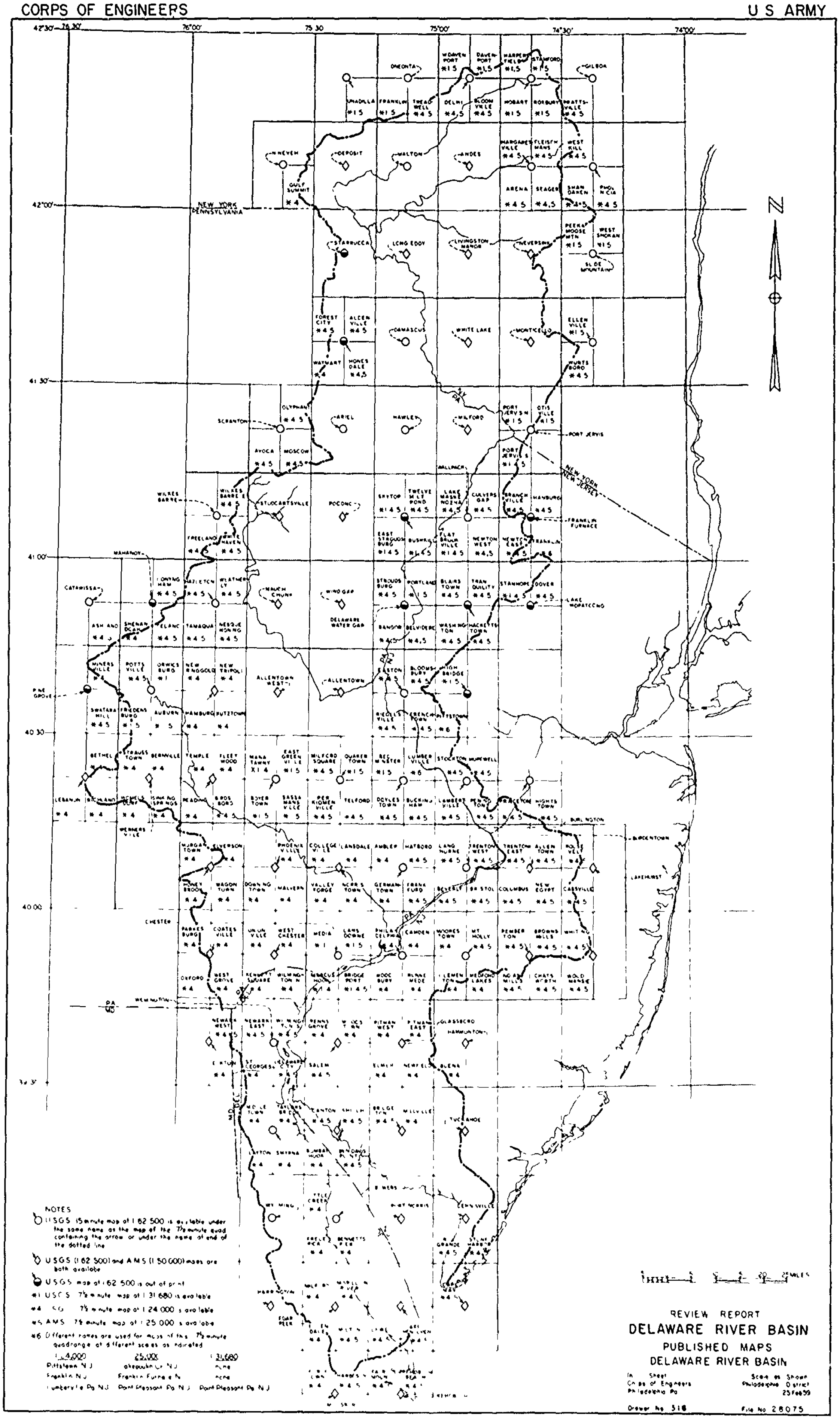

PLATE 2

Central Region includes rocks of many different ages and origins. In addition to unmetamorphosed sedimentary rocks such as limestone, shale, sandstone and conglomerate, there is a great variety of metamorphic and igneous rocks, ranging from marble, slate, quartzite, schist and gneiss to granite, gabbro and diabase. Structurally, complex folding and/or faulting has occurred throughout the Central Region. The northeast portion of the Central Region was glaciated. Glacial drift is thick only in areas covered by terminal or recessional moraines.

d. The Lower Region. The Lower Region extends as a low, monotonous plain from the Fall Line, shown as the northern edge of the Cretaceous beds on the map, to the sea. The "rocks" of this region, the youngest in the basin, are primarily unconsolidated to semiconsolidated sand, silt and clay, which outcrop near the Delaware as thin sheets and thicken to great wedges southeastward. While none of the Lower Region was glaciated, alluvial sand and gravel of glacial age were deposited over much of the area.

19. Subsurface Data and Investigation. Subsurface explorations were accomplished by means of borings, seismic survey, and test pits. At 11 of the proposed dam sites bore holes were drilled to determine the depth of bedrock and the type of bedrock under the surface. Results of these borings are shown in geologic plates accompanying other drawings for the 11 projects. Bear Creek and Prompton Dam sites were extensively drilled before construction was undertaken and results of those borings were shown on contract drawings accompanying specifications for construction of the projects. At the Blue Marsh site, three borings were made along a relatively thin reservoir rim area north of the dam site to determine what protective construction would be required. Results of a seismic survey to determine bedrock elevations beneath the overburden at the Tocks Island site are included with other data for this project. At dam sites where visual inspection and numerous outcrops indicated the shallow presence of bedrock, and where field reconnaissance indicated that there are sufficient quantities of suitable materials for the embankment, subsurface explorations were not considered necessary and were not made. The "assumed rock line" as shown on the drawings was based on data from subsurface explorations described in this appendix and on outcrops found by field investigations.

20. Construction Materials. On 16 of the 19 projects, visual field inspections and data from drill holes indicated that various earth and rock materials required for the embankment would be available either from spillway excavation and/or from borrow areas near the dam. However, at three of the sites --- Beltzville, Evansburg and Newtown --- earth samples were taken by making auger borings and test pits. The locations and geologic logs of such borings and test pits are shown on drawings which accompany the description of each of these

three projects. From the limited data of survey scope described above, it appears that embankment material will be obtainable from areas as indicated in the description of each project.

21. Cost Estimates. Detail estimates of cost of constructing each project included in the comprehensive plan were made in accordance with the Corps of Engineers Manuals 1110-2-1301 (p. 14); 110-2-1303 (appendix 1); and 1120-2-101 (p. 57). The cost of each project has been estimated on the basis of prices prevailing in January 1959. At that time the Engineering News-Record index of construction costs stood at 778.28 based on an index of 100 in 1913. Real estate estimates were made throughout 1959 when the value of the real estate dollar varied from 40.44 cents (Jan) to 38.79 cents (Dec), average 39.62 cents. These dollar values are based on 1939 = 100 cents as reported by the Real Estate Research Corp., 73 West Monroe Street, Chicago 3, Illinois. It will be noted that the items of easements required for the projects are listed in the project cost estimate under the subheading "Lands and Damages." The applicable acreages are also given. These areas are also included in those lands to be acquired in fee title for recreation development. The difference between the easement cost and the fee title cost is included in the real estate estimate under the subheading "Recreation". The area for recreation real estate includes the above-mentioned easement acreage. Division was made in this manner to facilitate identification of separable costs.

22. Projects. A brief descriptive presentation, along with pertinent tables and plates, is included for each project. For purposes of this appendix, the prljects have been arranged in two categories -- those major control projects with short term and/or long term storage, and those projects to be developed initially for recreation with storage potential for ultimate development. Because of the long period before full development of projects in the latter category, the cost estimates presented herein are confined to the total cost for the project and the cost of minimum land to preserve the site. Projects in both categories are listed alphabetically in table U-1.

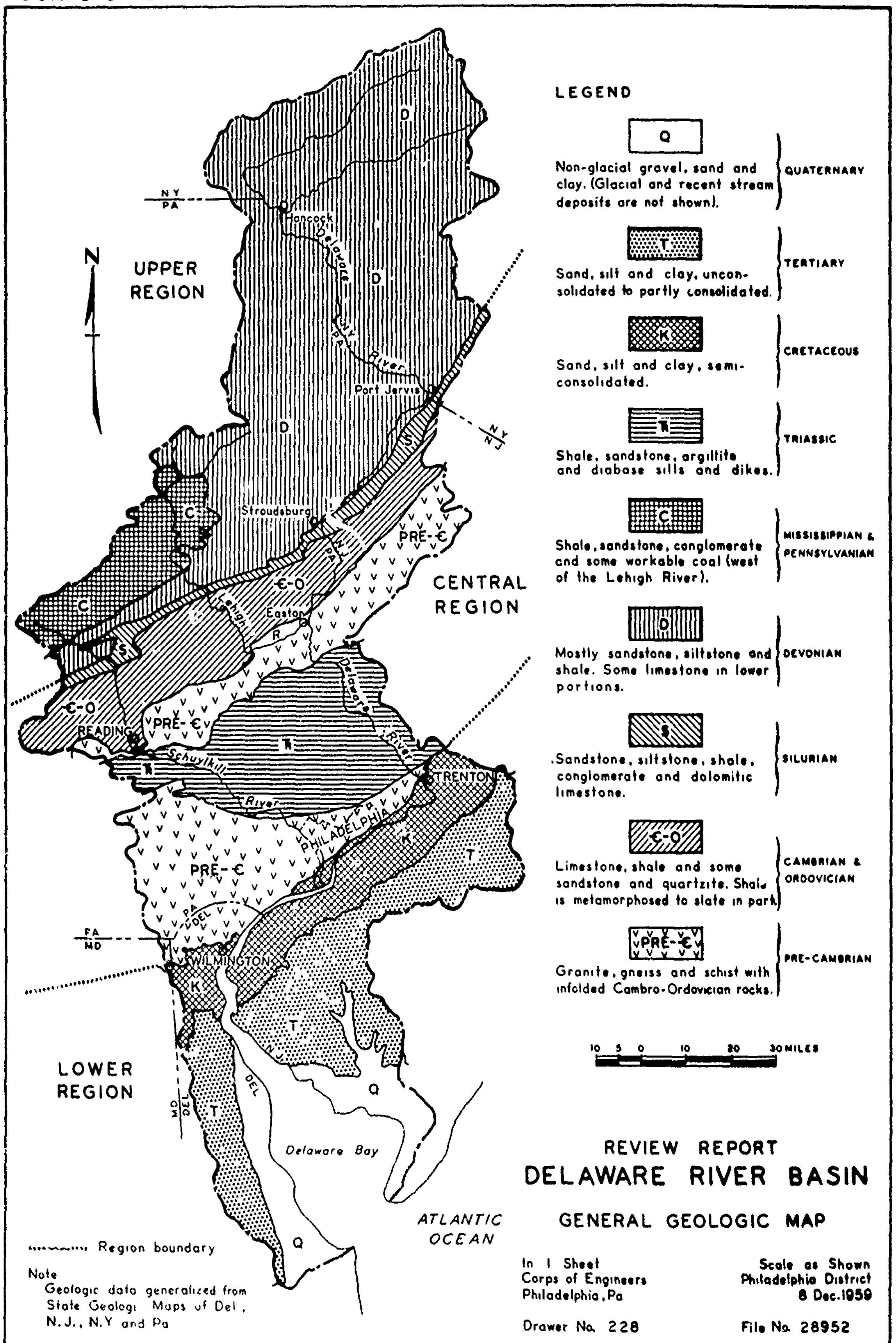
LEGEND
Q
Non-glacial gravel, sand and clay. (Glacial and recent stream deposits are not shown).
QUATERNARY
T
Sand, silt and clay, unconsolidated to partly consolidated.
TERTIARY
K
Sand, silt and clay, semi-consolidated.
CRETACEOUS
Shale, sandstone, argillite and diabase sills and dikes.
TRIASSIC
C
Shale, sandstone, conglomerate and some workable coal (west of the Lehigh River).
MISSISSIPPIAN & PENNSYLVANIAN
D
Mostly sandstone, siltstone and shale. Some limestone in lower portions.
DEVONIAN
S
Sandstone, siltstone, shale, conglomerate and dolomitic limestone.
SILURIAN
Є-O
Limestone, shale and some sandstone and quartzite. Shale is metamorphosed to slate in part.
CAMBRIAN & ORDOVICIAN
PRE-Є
Granite, gneiss and schist with infolded Cambro-Ordovician rocks.
PRE-CAMBRIAN
10 5 0 10 20 30 MILES
N
UPPER REGION
CENTRAL REGION
LOWER REGION
NY PA
Hancock
Delaware River
Port Jervis
NY NJ
Stroudsburg
NJ PA
Easton
Lehigh R
READING
Schuylkill River
TRENTON
PHILADELPHIA
PA DEL
PA MD
WILMINGTON
MD DEL
DEL
Delaware Bay
ATLANTIC OCEAN
Region boundary
Note
Geologic data generalized from State Geologi Maps of Del, N.J., N.Y and Pa
REVIEW REPORT
DELAWARE RIVER BASIN
GENERAL GEOLOGIC MAP
In 1 Sheet
Corps of Engineers
Philadelphia, Pa
Scale as Shown
Philadelphia District
8 Dec. 1959
Drawer No. 228
File No. 28952

PLATE 3

TABLE U-1
LIST OF PROJECTS

Project	Stream	Type of Storage
	MAJOR CONTROL PROJECTS	
Aquashicola	Aquashicola Cr.	long term and short term
Bear Creek, raised	Lehigh R.	long term and short term
Beltzville	Pohopoco Cr.	long term and short term
Blue Marsh	Tulpehocken Cr.	long term and short term
Maiden Creek	Maiden Cr.	long term and short term
Prompton, modified	Lackawaxen R.	long term and short term
Tocks Island	Delaware R.	long term and short term
Trexler	Jordan Cr.	long term and short term
Christiana	Christina R.	long term
Hawk Mountain	E. Br. Del. R.	long term
Newark	White Clay Cr.	long term
	PROJECTS FOR DEVELOPMENT FOR RECREATION 1/	
Evansburg	Skippack Cr.	long term
French Creek	French Cr.	long term
Hackettstown	Musconetcong R.	long term
New Hampton	Musconetcong R.	long term
Newtown	Neshaminy Cr.	long term
Paulina	Paulins Kill	long term
Pequest	Pequest R.	long term
Tohickon	Tohickon Cr.	long term

1/ It is proposed that these projects be initially developed for recreation, with storage potential for ultimate development.

23. Aquashicola Project

a. Aquashicola dam, as proposed, would be located across the valley of Aquashicola Creek about 4-1/2 miles upstream of its confluence with the Lehigh River and about 3 miles east of Palmerton, Pennsylvania. This site is about one mile downstream from the confluence of Buckwha Creek with Aquashicola Creek. The drainage area above this site is 66 square miles. Data on the basic dimensions of the project are as follows:

Capacities

Long term, 25,000 ac.-ft., stream bed to elevation 483
Short Term, 20,000 ac.-ft., between elevation 483 and elevation 503

Elevations

Top of dam, 523
Spillway crest, 503
Outlet, upstream invert, 425
Stream bed at dam, 420

Areas

Reservoir at elevation 483, 840 acres
Reservoir at elevation 503, 1,130 acres

b. The dam site is located in an area of Paleozoic sedimentary rock, strongly folded, eroded and then subjected to Pleistocene glaciation. The underlying bedrock is Lower Devonian and Upper Silurian limestone, sandsone and shale. The right (north) abutment displays a terrace of waterlaid material 30 to 50 feet thick held up by the Devonian Oriskany sandstone. Silurian Bloomsburg red sandstone and shale underlay the overburden blanket on the left abutment along the north slope of Blue Mountain. Fine silt, sand and gravel, of low to medium permeability with considerable amounts of surface boulders, make up the flood plain overburden which provides a thick blanket over the impure limestone in the center of the valley. Three bore holes made at the site provided data shown on plate 5.

c. The dam would consist of a compacted earth fill stretching approximately 2,000 feet across the valley with a concrete section and spillway 160 feet long founded on rock at the left (south) end. Material for this embankment would come from borrow areas along the county road upstream from the dam. The dam will rise 103 feet above the existing stream and will have a compacted earth cutoff 30 feet deep to control leakage from the reservoir. The top of dam at elevation 523 will be 20 feet above the spillway crest at elevation 503. Outlet sluices through the spillway will provide for water releases. Diversion during construction would be made over low blocks in the

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spillway section.

d. The reservoir created by this dam (up to the spillway crest at elevation 503) would be 90 feet deep at the dam and would extend five miles up Aquashicola Creek from the dam and six miles up Buckwha Creek from the dam. It will make necessary the relocation of an oil pipeline, a waterline, roads, 7.3 miles of railroad, quarry equipment, rural residents and the community of Little Gap. The cost estimates include amounts for these items. Nine hundred acres would be cleared (up to elevation 487, the elevation of the 5-year frequency of filling). No commercial mineral deposits exist in the reservoir area, except a sandstone quarry southeast of Little Gap operated by the North American Refractories Company. Although the reservoir will not flood this quarry it will be necessary to relocate crushing and processing equipment. Sand from the quarry is shipped by rail cars at the approximate rate of five cars per day; and this traffic constitutes nearly all the traffic on the Chestnut Ridge Railroad. Before final designs are made, consideration will be given to alternate means of transporting sand from the quarry in order to provide the necessary service at a minimum total cost.

TABLE U-2
AQUASHICOLA PROJECT COST ESTIMATE

Description	Estimated Cost
Lands & Damages	$ 1,707,000
Relocations	5,419,000
Reservoir Clearing	814,000
Dam & Appurtenant Works	7,444,000
Fish & Wildlife, Mitigation of Losses 1/	-
Access Road	75,000
Recreation 2/	1,366,000
Building, Grounds, Utilities	31,000
Engineering and Design	1,240,000
Supervision and Administration	1,378,000
TOTAL PROJECT COST	$19,474,000

1/ Appendix J contains means of mitigating losses to stream fisheries, game habitat, and public hunting expected to be caused by the project. These means include the acquisition of public fishing rights and development of public use facilities along 10 miles of existing trout streams in Carbon or Monroe County, Pennsylvania, and in habitat improvement and public hunting opportunity on 1,200 acres of land needed in Monroe or Carbon County, Pennsylvania. The cost required to provide these mitigations is a project cost, and while omitted from the estimate above is taken into account in the economic analyses in Appendix V.

2/ This cost includes engineering, design, supervision, and administration.

TABLE U-2
AQUASHICOLA PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and severance, 900 ac.	job	l.s.	-	$ 230,000
Improvements, 110 units	job	l.s.	-	1,016,000
Resettlement, 110 units	job	l.s.	-	64,000
Easement & resettlement, 360 ac.	job	l.s.	-	99,000
Contingencies, approx. 15%				212,000
Acquisition				86,000
Total - Lands and Damages				1,707,000
Relocations				
Highways				
Improve existing secondary hard surface road	mile	$45,000	4.2	189,000
New secondary hard surface road	mile	75,000	10.0	750,000
New bridges (3) for secondary hard surface road	job	l.s.	-	462,000
Contingencies, approx. 25%				350,000
Subtotal, Highways				1,751,000
Railroad				
Relocate, Aquashicola to Chapple Creek	mile	186,000	7.3	1,360,000
New bridges (2) for railroad	job	l.s.	-	1,050,000
Contingencies, approx. 25%				600,000
Subtotal, Railroad				3,010,000
Utilities				
Relocate service pole line	mile	5,000	10	50,000
Reinforce transmission line	job	l.s.	-	25,000
Relocate petroleum line	mile	50,000	1.8	90,000
Relocate 30" water line	mile	85,000	4.3	365,000
Contingencies, approx. 25%				130,000
Subtotal, Utilities				660,000
Total - Relocations				5,419,000
Engineering and Design				486,000
Supervision and Administration				542,000

TABLE U-2
AQUASHICOLA PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing				
Agricultural land	acre	$80	160	$13,000
Recreation land	acre	210	10	2,000
Building & commercial sites	acre	50	100	5,000
Quarry	acre	-	20	-
Stream bed	acre	-	30	-
Woodland, light clearing	acre	80	150	12,000
Woodland, medium clearing	acre	210	360	76,000
Woodland, heavy clearing	acre	350	70	25,000
Dwellings	each	72	85	6,000
Farm units	each	500	11	6,000
Commercial buildings	each	400	14	6,000
Quarry equipment, relocation				500,000
Contingencies, approx. 25%				163,000
Total - Reservoir Clearing				814,000
Engineering and Design				74,000
Supervision and Administration				81,000
Dam and Appurtenant Works				
Embankment				
Clearing & grubbing	acre	$600	30	$18,000
Diversion & care of stream	job	l.s	-	60,000
Stripping for dam	c.y.	0.80	90,000	72,000
Excavation, cutoff trench	c.y.	0.90	100,000	90,000
Excavation, impervious borrow	c.y.	0.55	700,000	385,000
Excavation, pervious borrow	c.y.	0.55	750,000	412,000
Foundation preparation	s.y.	7.00	1,000	7,000
Impervious fill, compacted	c.y.	0.30	630,000	189,000
Random fill, compacted	c.y.	0.30	280,000	84,000
Pervious fill, compacted	c.y.	0.30	490,000	147,000
Additional compaction	hour	15.00	1,000	15,000
Drilling & pressure grouting	l.f.	9.00	5,000	45,000
Filter material	c.y.	4.20	95,000	400,000

TABLE U-2
AQUASHICOLA PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works - Continued				
Embankment - Continued				
Riprap	c.y.	$ 2.00	50,000	$100,000
Topsoil & seeding	c.y.	0.70	20,000	14,000
Contingencies, approx. 20%				408,000
Subtotal, Embankment				2,446,000
Spillway				
Excavation, common	c.y.	0.75	400,000	300,000
Excavation, rock	c.y.	5.00	50,000	250,000
Close line drilling	s.f.	4.00	6,000	24,000
Foundation preparation	s.y.	7.00	3,000	21,000
Backfill	c.y.	1.20	5,000	6,000
Drilling & pressure grouting	l.f.	9.00	2,000	18,000
Drilling & grouting anchors	l.f.	10.00	1,500	15,000
Drilling drain holes	l.f.	5.00	4,000	20,000
Concrete, mass	c.y.	25.00	100,000	2,500,000
Concrete, stilling basin	c.y.	30.00	2,400	72,000
Cement	bbls	6.00	105,000	630,000
Reinforcing steel	lbs	0.20	400,000	80,000
Rubber water stops	l.f.	3.00	4,000	12,000
Miscellaneous metal	lbs	0.60	50,000	30,000
Sluice gates	lbs	0.60	150,000	90,000
Operating house superstructure	job	l.s.	-	25,000
Spiral stairway	job	l.s.	-	5,000
Gate operating system	job	l.s.	-	12,000
Bypass system	job	l.s.	-	8,000
Float well & drain system	job	l.s.	-	15,000
Lighting & power system	job	l.s.	-	11,000
Heating & ventilating system	job	l.s.	-	6,000
Trolley hoist; 5 ton	job	l.s.	-	9,000
Chain hoist; 1-1/2 ton	job	l.s.	-	1,000
Tile gage	job	l.s.	-	3,000
Guard rail	l.f.	4.00	500	2,000
Contingencies, approx. 20%				833,000
Subtotal, Spillway				4,998,000
Total - Dam and Appurtenant Work				7,444,000
Engineering and Design				670,000
Supervision and Administration				744,000

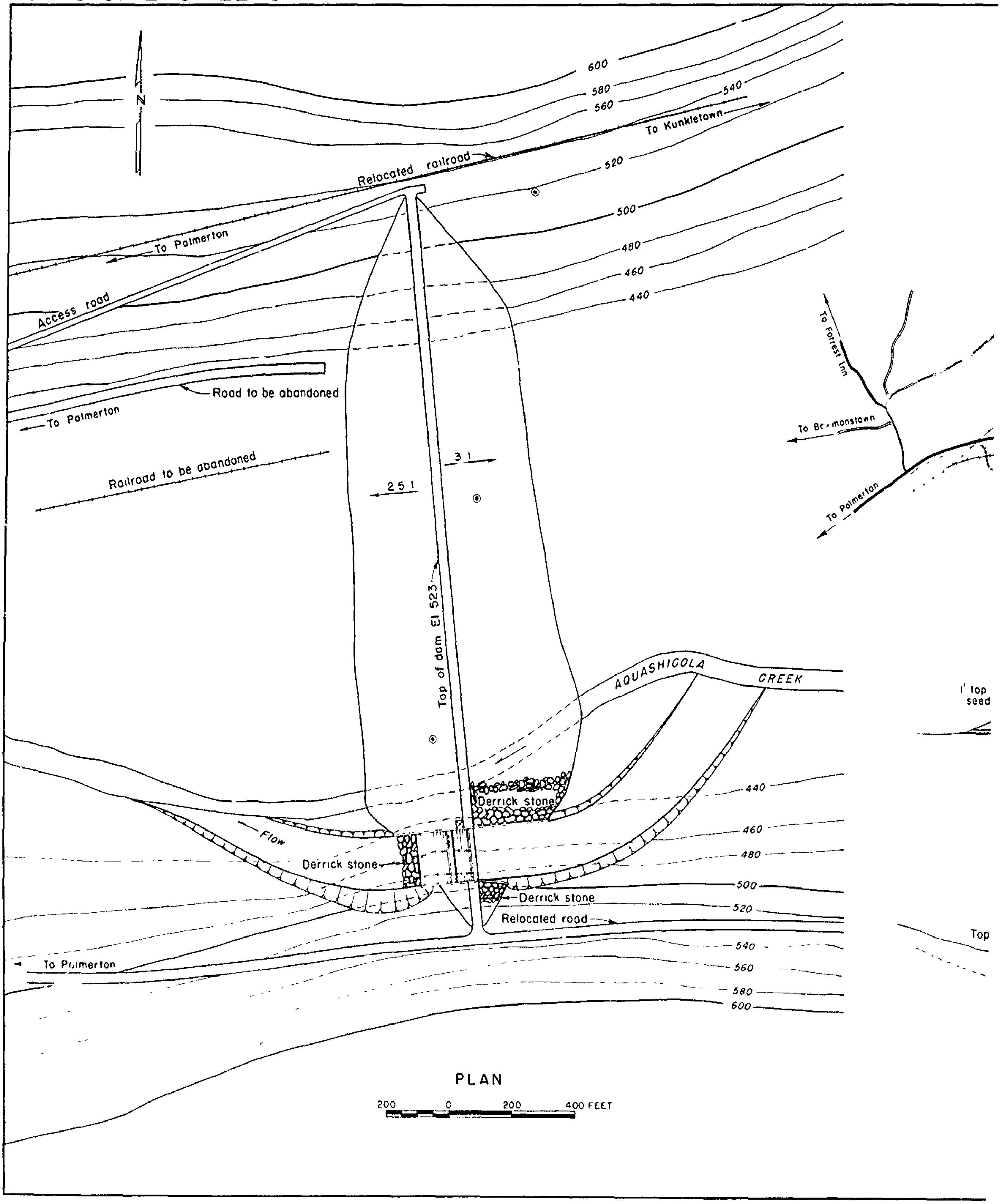
TABLE U-2
AQUASHICOLA PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Access Road				
New road	mile	$ 60,000	1	$ 60,000
Contingencies, approx. 25%				15,000
Total - Access Road				75,000
Engineering and Design				7,000
Supervision and Administration				8,000
Recreation				
Facilities 1/	job	l.s.	-	713,000
Real Estate, 1250 acres	job	l.s.	-	653,000
Total - Recreation				1,366,000

1/ Includes contingencies, engineering, design, supervision, and administration

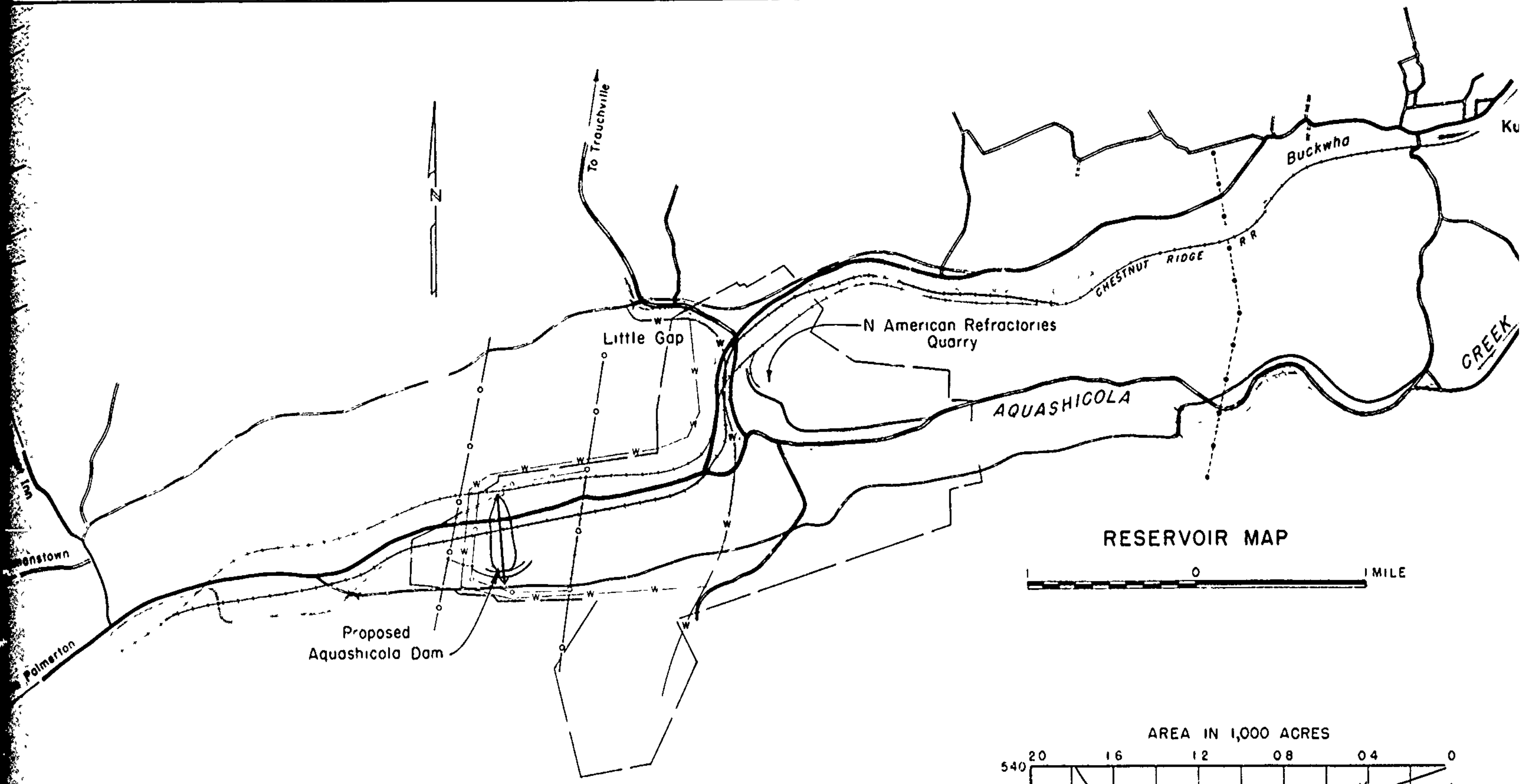
Description	Unit	Unit Price	Quantity	Cost
Building, Grounds, Utilities				
Administration, maintenance, building, etc.	job	l.s.		25,000
Contingencies, approx. 25%				6,000
Total - Building, Grounds, Utilities				31,000
Engineering and Design				3,000
Supervision and Administration				3,000

CORPS OF ENGINEERS

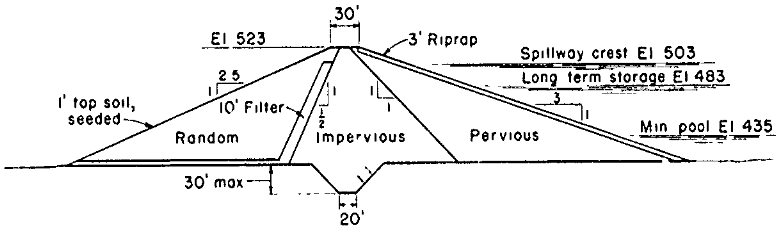


PLAN

200 0 200 400 FEET

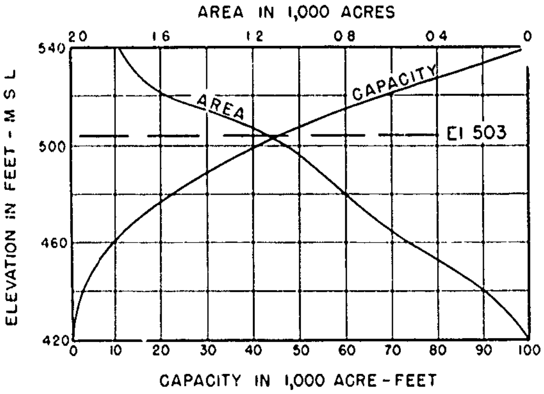


RESERVOIR MAP

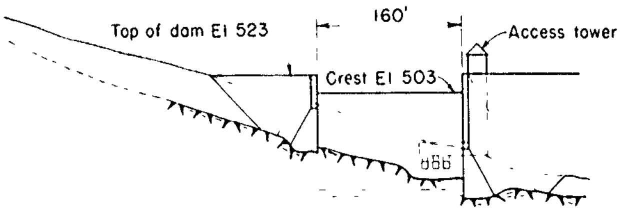


TYPICAL SECTION - DAM

100 0 100 200 FEET

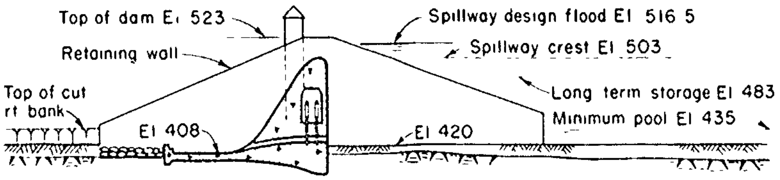


RESERVOIR AREA AND CAPACITY CURVES



SPILLWAY
(LOOKING DOWNSTREAM)

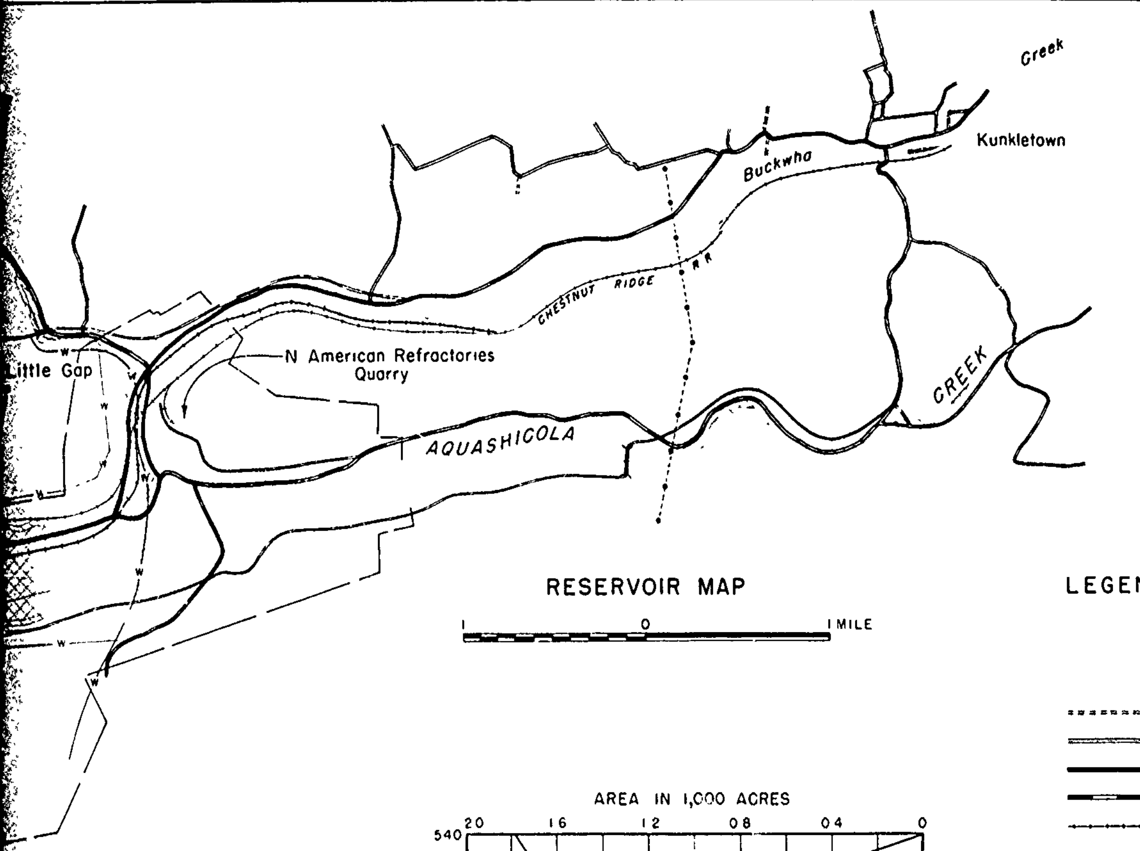
100 0 100 200 FEET



SPILLWAY SECTION

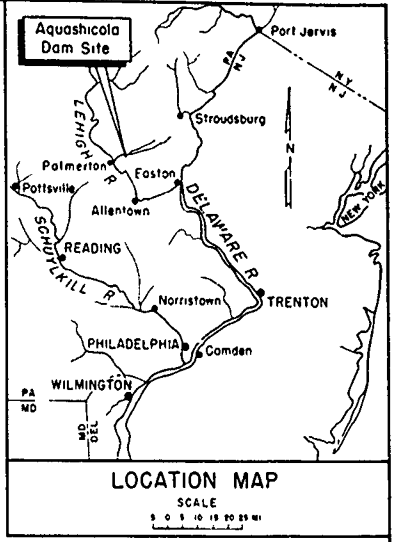
100 0 100 200 FEET

U.S. ARMY



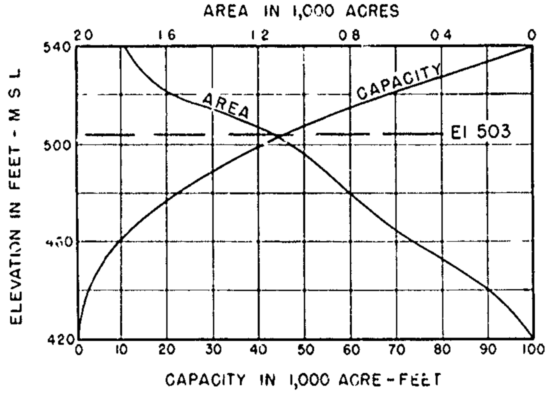
RESERVOIR MAP

1 0 1 MILE

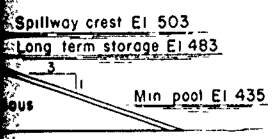


LOCATION MAP

SCALE



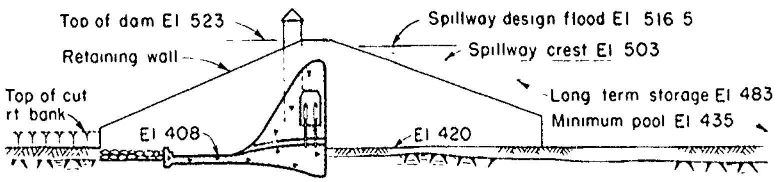
RESERVOIR AREA AND CAPACITY CURVES



LEGEND

Reservoir at El 503
Long Term Storage El 483
Existing Stream
Dirt Road
Graded Road
Hard Surface, Heavy Duty Road
Secondary Hard Surface Road
Existing Railroad
Existing Power Line
Existing Petroleum Line
Existing Water Line
Proposed Relocated Hard Surface Heavy Duty Road
Proposed Relocated Secondary Hard Surface Road
Proposed Relocated Railroad
Proposed Relocated Petroleum Line
Proposed Relocated Water Line
Land Acquisition for Recreation Development

Drill Hole



SPILLWAY SECTION

100 0 100 200 FEET

REVIEW REPORT DELAWARE RIVER BASIN

AQUASHICOLA PROJECT

In 1 Sheet

Scale as Shown

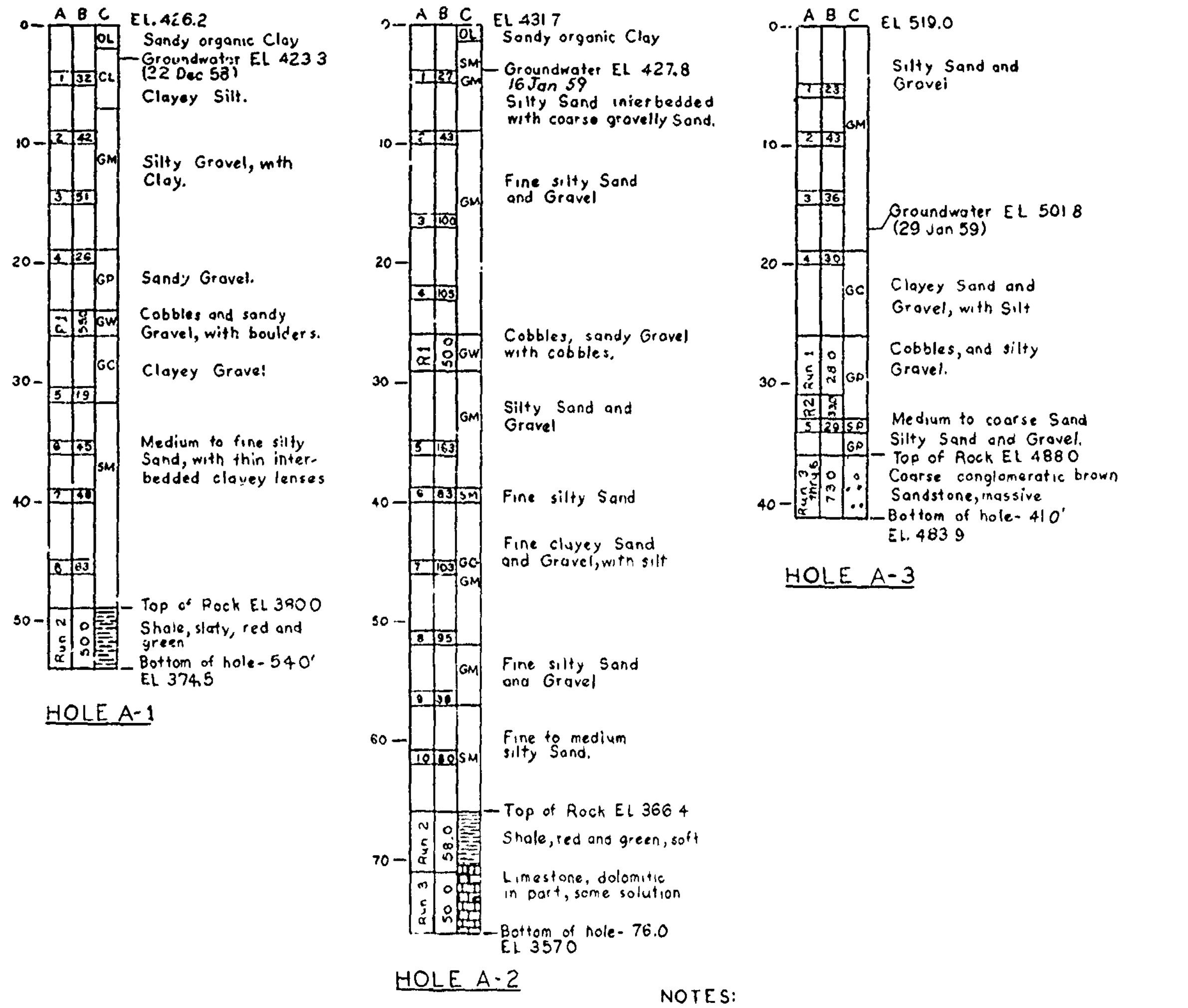
Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

Drawer No 228

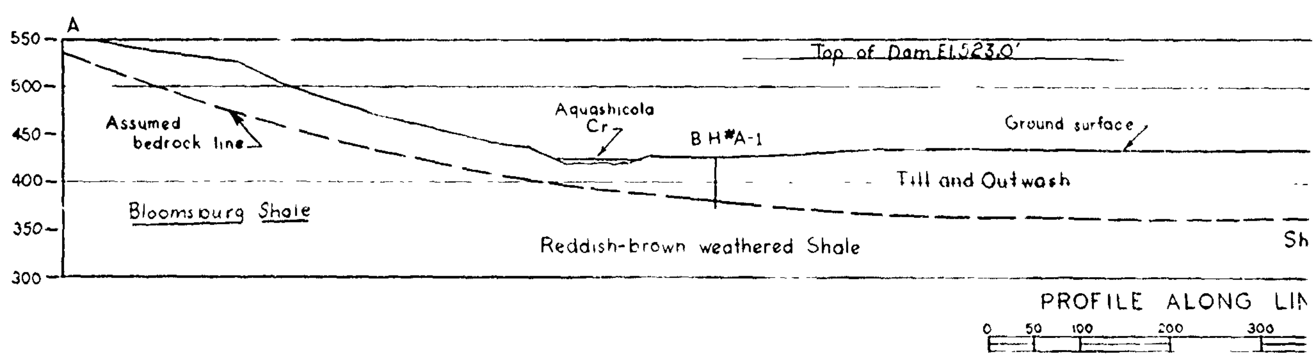
File No 29093

CORPS OF ENGINEERS



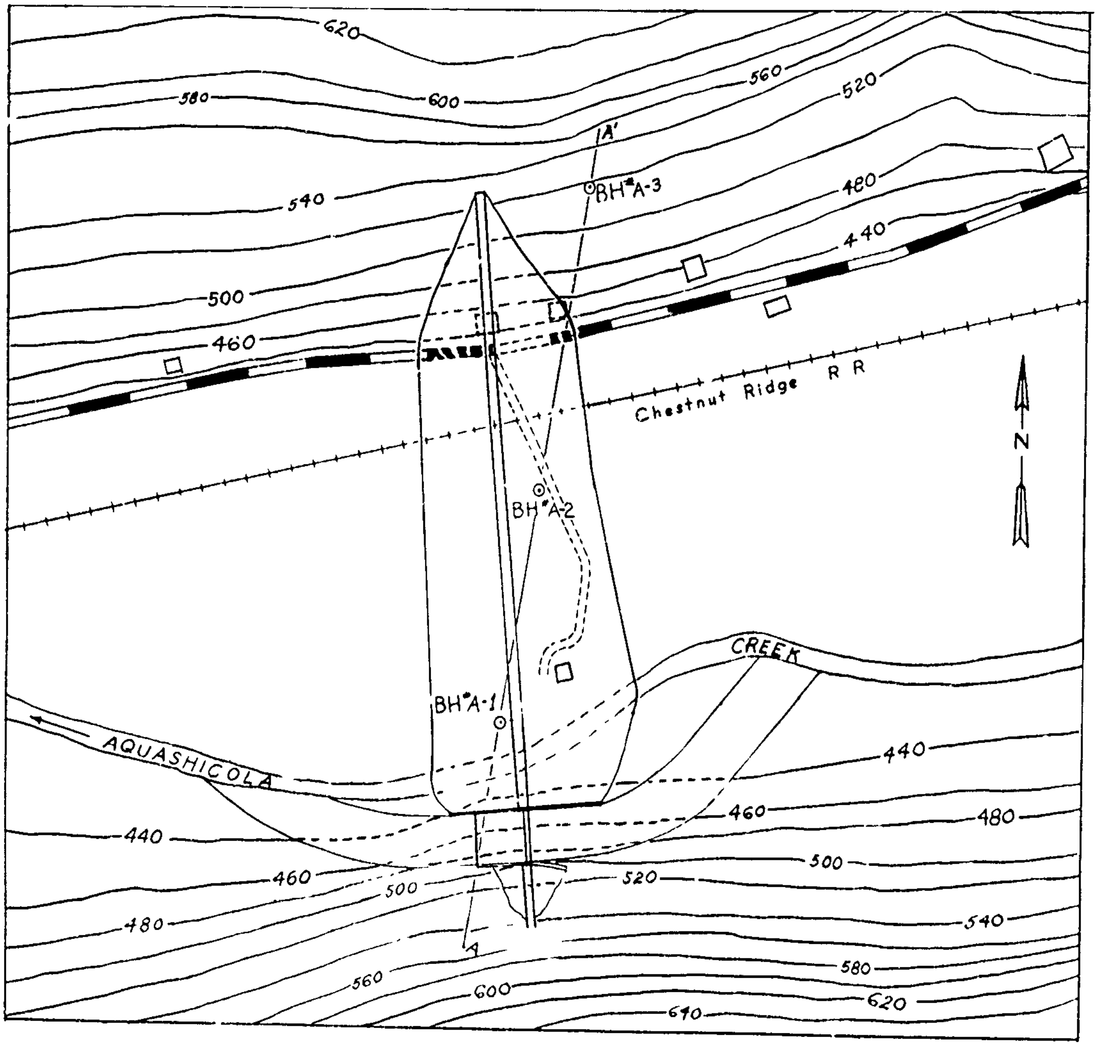
NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of spoon samples and core
2. Column "A" refers to the sample number or core run number
3. Column "B" refers to the number of blows a 140 lb hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered, or the per-cent recovery of a specified core run
4. Column "C" is a visual classification of the materials encountered, using the Unified Soils Classification System symbols, and graphi
5. All elevations based on mean sea level datum
6. Borings by U.S. Testing Co Phila, Pa, Dec 1958, Jan 1959



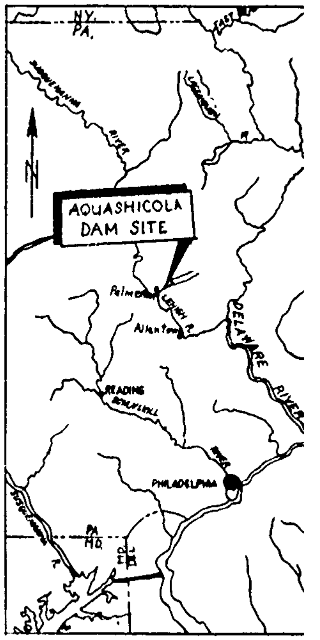
PROFILE ALONG LIN

0 50 100 200 300



SITE MAP

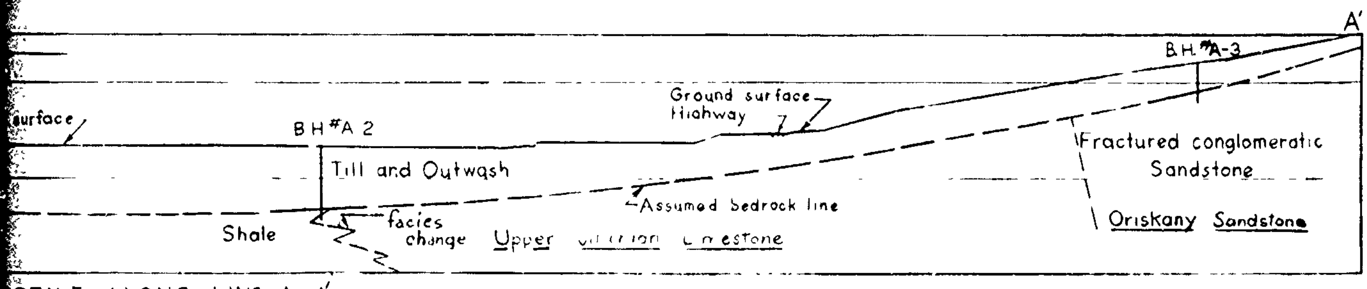
0 200 500 1000 1500 FT.



LOCATION M

ngs are based
core.
re run number
140 lb hammer
sampling spoon
d, or the per-

materials encountered,
System symbols, and graphic rock symbols.
datum
1958, Jan 1959



OFILE ALONG LINE A-A'

100 200 300 400 500 FT

REVIEW REPORT DEL

AQUASHICOLA

GEOLOGI

In 1 Sheet
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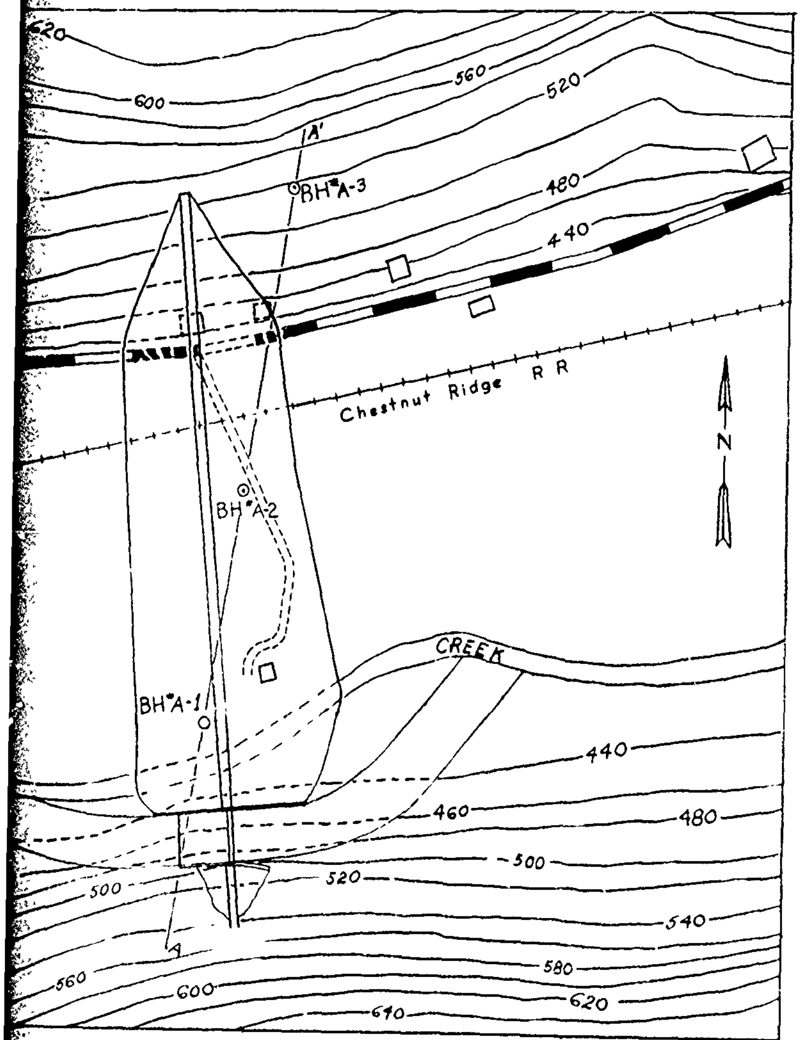
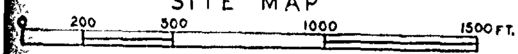
Philadelphia, Pa

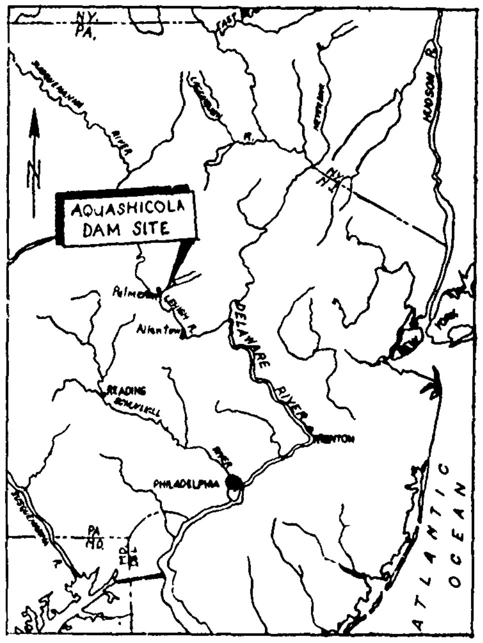
Drawer No. 228

U. S. ARMY

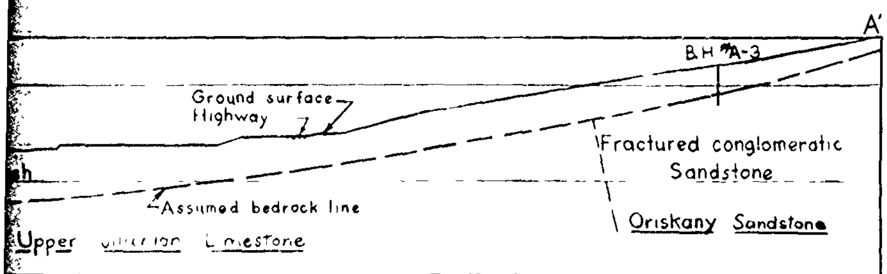


SITE MAP





LOCATION MAP



REVIEW REPORT DELAWARE RIVER BASIN

AQUASHICOLA PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
13 Jan 60

Drawer No. 228

File No 29078

PLATE 5

24. Bear Creek Project

a. Bear Creek Dam, now under construction and scheduled for completion in 1960, is located on the Lehigh River 75 miles above its confluence with the Delaware River and about 5 miles north of White Haven, Pennsylvania. At this location the dam controls 288 square miles of drainage area. The dam, now being constructed, will rise to elevation 1,474 and is designed to hold water only for a short period after a flood.

b. The modifications proposed to make this dam serviceable for long term storage in addition to short term storage would involve:

1. moving and raising the spillway crest 31 feet to elevation 1,481;
2. raising the dam to elevation 1,503;
3. raising and strengthening the intake control tower;
4. adding 130 feet of concrete conduit to the downstream end of the outlet tunnel;
5. constructing new dikes and raising existing dikes north of the dam.

c. Data on basic dimensions of the project, after raising the dam and other structures, are as follows:

Capacities
Long term, 72,000 ac.-ft., stream bed to elevation 1,425
Short term, 108,000 ac.-ft., between elevation 1,425 and elevation 1,481

Elevations
Top of dam, 1,503
Spillway crest, 1,481
Outlet, upstream invert, 1,250
Stream bed at dam, 1,240

Areas
Reservoir at elevation 1,425, 1,280 acres
Reservoir at elevation 1,481, 2,600 acres

d. Bedrock, exposed intermittently along both abutments at the dam site, is extremely hard, silica-cemented gray sandstone and conglomerate, containing quartz pebbles with occasional beds of red sandstone or black to gray shale. In the valley it is covered by a maximum of 100 feet of glacial outwash, consisting of boulders, sand and gravel fill. This glacial outwash was excavated and replaced by core material during construction of Bear Creek dam. Data regarding subsurface formations and materials in vicinity of the dam site are shown on 10 drawings in "Plans for Bear Creek Reservoir" issued in

March 1957 by the Philadelphia District.

e. The modified dam would rise 263 feet above the stream bed with a length of 3,500 feet. Material for enlargement of the embankment would be obtained from previously developed borrow areas about one-half mile northeast of the north end of the dike and about one mile upstream from the dam along the left bank of Bear Creek. The spillway would be cut through rock to the right (north) of the dam and farther north a dike 4,600 feet long would fill a swale in the reservoir rim. The existing control tower would be modified to strengthen and raise it so as to provide for operation of the existing three gates which would control flow through the 16-foot diameter outlet tunnel. The downstream end of the tunnel would be extended to permit addition of fill material to the dam. Care of the river during construction would be met by partially closing the existing control gates and limiting flow past the construction work in progress to a minimum. Temporary pipes or flumes would be used to carry water past the tunnel extension work, and a low dike would be used to protect the placement of additional embankment material in the stream bed.

f. The reservoir for long-term storage would be 185 feet deep at its maximum and would extend 7.0 miles up the Lehigh River and 4.0 miles up Bear Creek from the dam. This reservoir would necessitate the purchase of land to be submerged on which flood easements have already been taken, and would require the acquisition of additional flood easements at higher elevations. No economically valuable mineral deposits would be flooded. Only one road along Bear Creek would require additional relocation.

TABLE U-3
BEAR CREEK PROJECT COST ESTIMATE

Description	Estimated Cost
Lands & Damages	$ 343,000
Relocations	797,000
Reservoir Clearing	205,000
Dam & Appurtenant Works	5,667,000
Fish & Wildlife, Mitigation of Losses 1/	-
Access Road	63,000
Recreation 2/	1,470,000
Building, Grounds, Utilities	31,000
Engineering and Design	609,000
Supervision and Administration	676,000
TOTAL PROJECT COST	$9,861,000

1/ Information regarding the acquisition of land and streams relative to recovery of fish and wild life losses comparable to that given for the Aquashicola project has not been received.
2/ This cost includes engineering, design, supervision, and administration

TABLE U-3
BEAR CREEK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and Severance (land now under easement), 1100 ac.	job	l.s.	-	$ 39,000
Improvements	"	"	-	60,000
Resettlement, 8 units	"	"	-	4,000
Easements, 800 ac.	job	l.s.	-	134,000
Contingencies, approx. 15%				36,000
Acquisition	ownership	$ 700	100	70,000
Total - Lands and Damages				343,000
Relocations				
Highways				
Relocate secondary hard surface road	mile	70,000	5.4	380,000
New bridge secondary hard surface road	job	l.s.	-	42,000
New bridge primary hard surface road	job	l.s.	-	168,000
Contingencies, approx. 25%				148,000
Subtotal, Highways				738,000
Utilities and cemeteries				
Elect. pole line	mile	5,000	5.4	27,000
Cemetery	job	l.s.		20,000
Contingencies, approx. 25%				12,000
Subtotal, Utilities and Cemeteries				59,000
Total - Relocations				797,000
Engineering and Design				72,000
Supervision and Administration				80,000

TABLE U-3
BEAR CREEK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing				
Recreational land	acre	$ 50	100	$ 5,000
Woodland, light clearing	acre	80	400	32,000
Woodland, medium clearing	acre	210	600	126,000
Dwellings	each	125	8	1,000
Contingencies, approx. 25%				41,000
Total - Reservoir Clearing				205,000
Engineering and Design				19,000
Supervision and Administration				20,000
Dam and Appurtenant Works				
Embankment				
Clearing and grubbing	acre	600.00	12	7,000
Stripping for dam	c.y.	1.00	48,000	48,000
Removal of riprap from existing dam	c.y.	0.80	394,000	315,000
Removal of fill from existing dam	c.y.	0.80	113,000	90,000
Excavation, common	c.y.	0.60	56,000	34,000
Excavation, impervious borrow	c.y.	0.70	355,000	248,000
Excavation, pervious drain, borrow	c.y.	0.60	172,000	103,000
Excavation, random and pervious borrow	c.y.	0.60	1,900,000	1,140,000
Fill, Impervious compacted	c.y.	0.20	324,000	65,000
Drain, Pervious	c.y.	0.20	157,000	31,000
Fill, Random, compacted	c.y.	0.20	1,965,000	393,000
Riprap, dumped	c.y.	0.40	522,000	209,000
Drilling and grouting pressure	l.f.	9.00	1,000	9,000
Backfill	c.y.	1.20	3,000	4,000
Contingencies, approx. 20%				539,000
Subtotal, Embankment				3,235,000

TABLE U-3
BEAR CREEK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity		Cost
Dam and Appurtenant Works - Continued					
Dikes					
Clearing and grubbing	acre	$600.00	16	$	10,000
Stripping for dikes	c.y.	1.00	52,000		52,000
Excavation, common	c.y.	0.60	18,000		11,000
Excavation, impervious borrow	c.y.	0.70	526,000		368,000
Fill, Compacted impervious	c.y.	0.20	480,000		96,000
Riprap, dumped	c.y.	0.40	25,000		10,000
Backfill	c.y.	1.20	3,000		4,000
Contingencies, approx. 20%					110,000
Subtotal, Dikes					661,000
Spillway					
Clearing and grubbing	acre	600.00	25		15,000
Stripping for spillway	c.y.	1.00	79,000		79,000
Excavation, common	c.y.	0.60	240,000		144,000
Excavation, rock	c.y.	2.40	126,000		302,000
Close line drilling	s.f.	4.00	400		2,000
Drilling and pressure grouting	l.f.	9.00	510		5,000
Drilling 3" holes	l.f.	5.00	6,000		30,000
Drilling and grouting anchors	l.f.	10.00	7,800		78,000
Concrete, broad-crested weir	c.y.	25.00	1,880		47,000
Concrete, retaining wall	c.y.	60.00	1,000		60,000
Cement	bbl.	6.00	3,600		22,000
Reinforcing steel	lb.	0.20	100,000		20,000
Contingencies, approx. 20%					161,000
Subtotal, Spillway					965,000

TABLE U-3
BEAR CREEK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works - Continued				
Outlet Works				
Remove existing outlet apron	c.y.	$30.00	370	$ 11,000
Drilling and pressure grouting holes for tunnel	l.f.	9.00	3,000	27,000
Concrete, new tunnel section	c.y.	60.00	4,670	280,000
Concrete, new outlet apron	c.y.	50.00	380	19,000
Operating house, complete	job	l.s.	-	30,000
Concrete, tower extension	c.y.	100.00	190	19,000
Concrete, deadweight collar	c.y.	50.00	1,500	75,000
Cement	bbl.	6.00	10,000	60,000
Reinforcing steel	lb.	0.20	92,000	18,000
Drilling and grouting anchors	l.f.	10.00	2,200	22,000
Rubber water stops	l.f.	3.00	1,400	4,000
Relocate generator set	job	l.s.	-	2,000
Spiral stairway extension	job	l.s.	-	1,000
30" Floatwell system extension	job	l.s.	-	1,000
Demolish operating house	job	l.s.	-	3,000
Relocate heating and ventilating systems	job	l.s.	-	4,000
Relocate power and light equipment	job	l.s.	-	7,000
Miscellaneous metal	job	l.s.	-	1,000
Service bridge	job	l.s.	-	88,000
Contingencies, approx. 20%				134,000
Subtotal, Outlet Works				806,000
Total - Dam and Appurtenant Works				5,667,000
Engineering and Design				510,000
Supervision and Administration				567,000

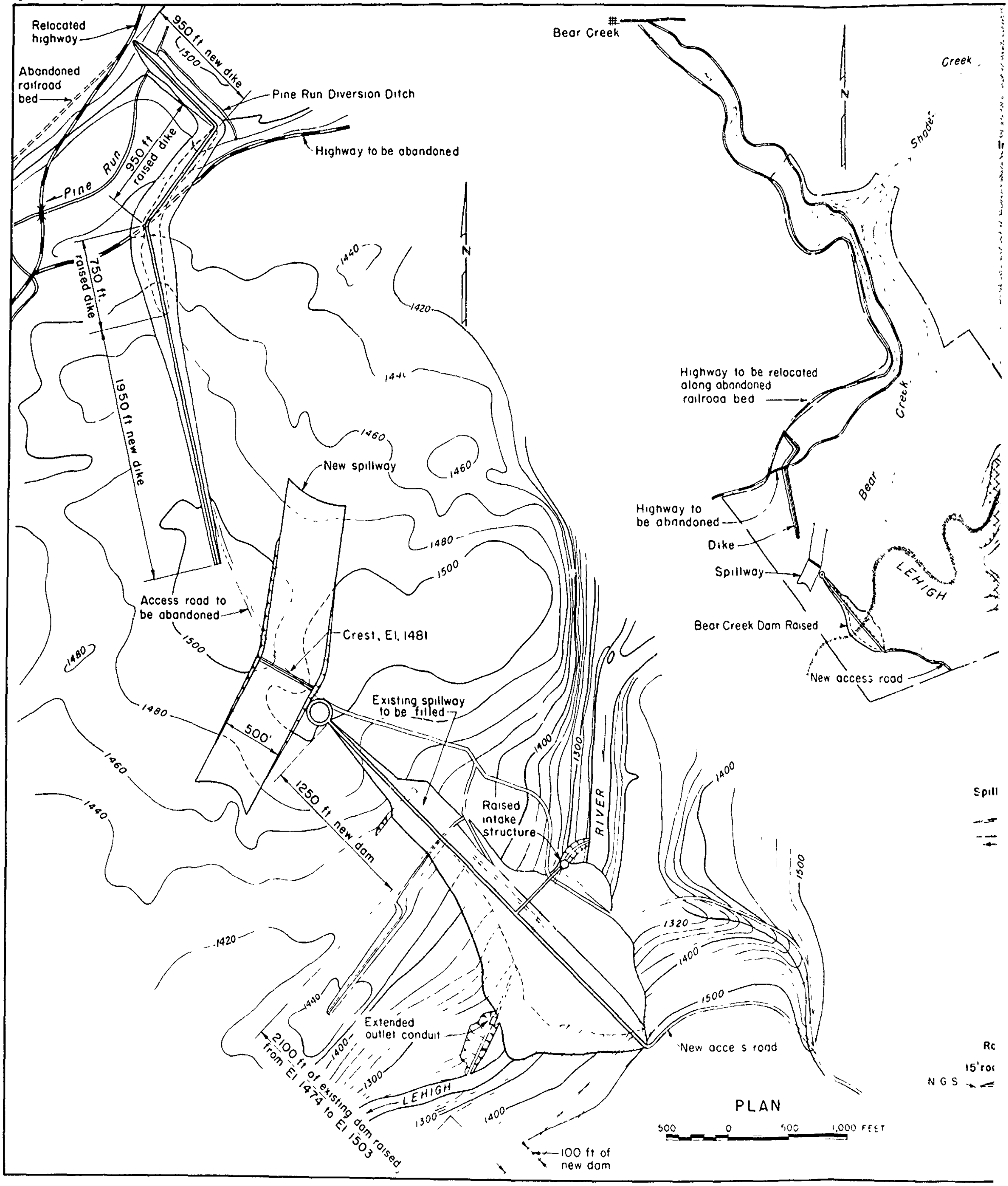
TABLE U-3
BEAR CREEK PROJECT COST ESTIMATE

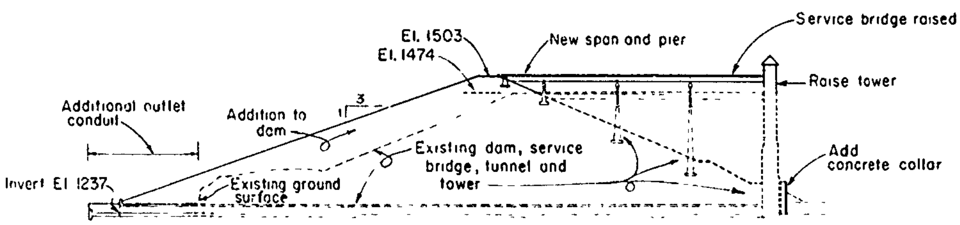
Description	Unit	Unit Price	Quantity	Cost
Access Road				
New Road	mile	$ 100,000	0.5	$ 50,000
Contingencies, approx. 25%				13,000
Total - Access Road				63,000
Engineering and Design				5,000
Supervision and Administration				6,000
Recreation				
Facilities 1/	job	l.s.	-	1,178,000
Real Estate, 2000 ac.	"	"	-	292,000
Total - Recreation				1,470,000

1/ Includes engineering, design, supervision and administration.

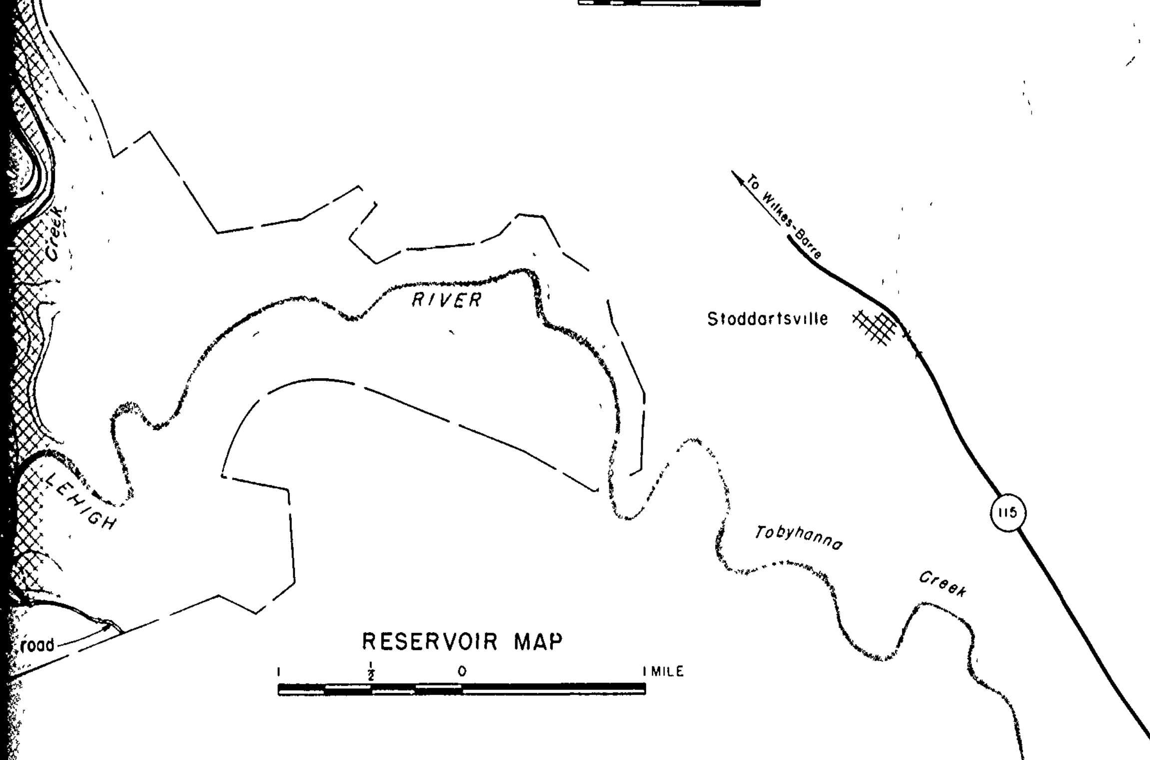
Description	Unit	Unit Price	Quantity	Cost
Building, Grounds, Utilities				
Administration, maintenance, building, etc.	job	l.s.	-	25,000
Contingencies, approx. 25%				6,000
Total - Building, Grounds, Utilities				31,000
Engineering and Design				3,000
Supervision and Administration				3,000

CORPS OF ENGINEERS

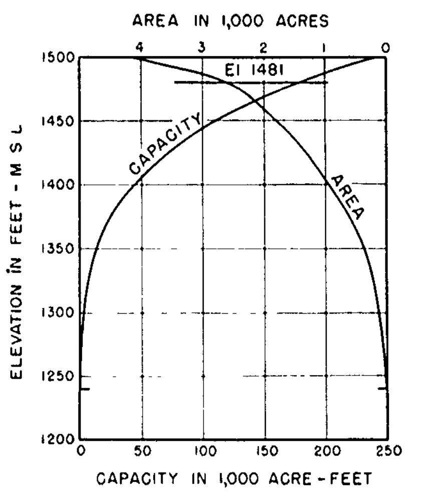




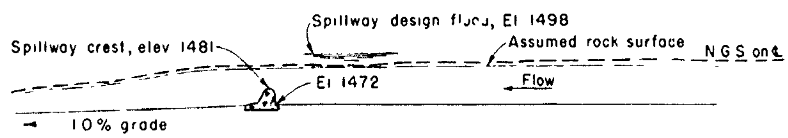
SECTION - OUTLET WORKS



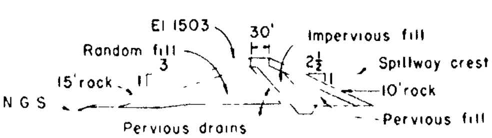
RESERVOIR MAP



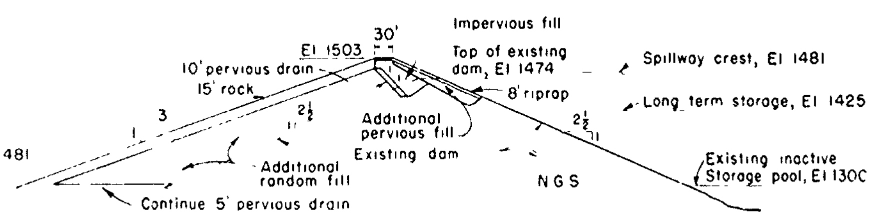
RESERVOIR AREA AND CAPACITY CURVES



PROFILE ALONG ℄ OF SPILLWAY



SECTION - NEW DAM



SECTION - RAISED DAM

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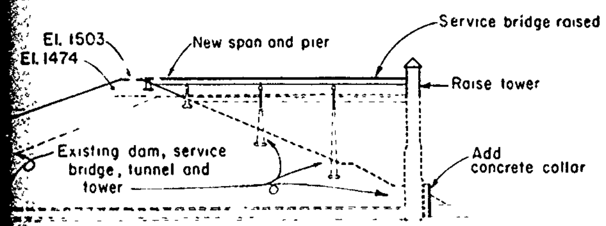
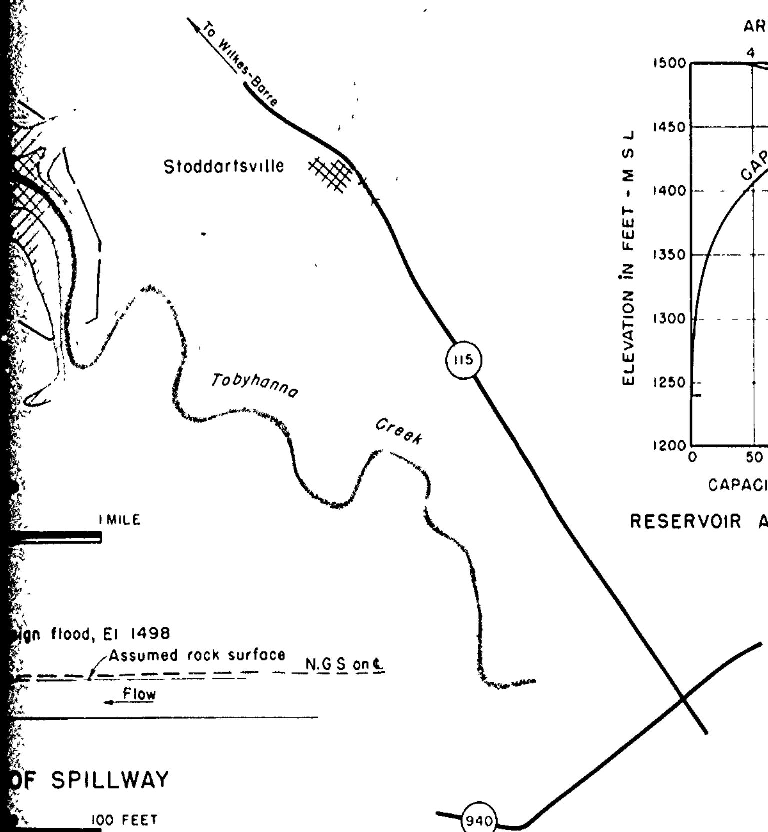
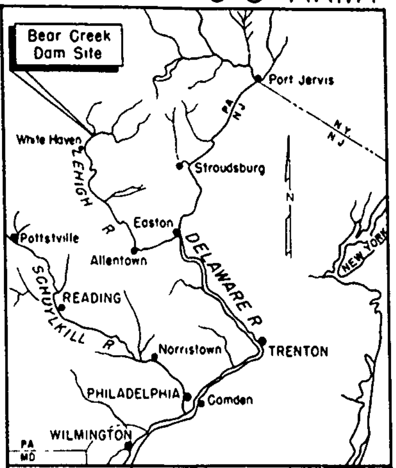


TION - OUTLET WORKS

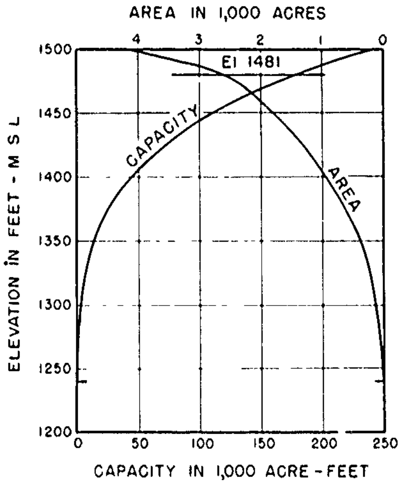
100 0 100 200 FEET





LOCATION MAP

SCALE

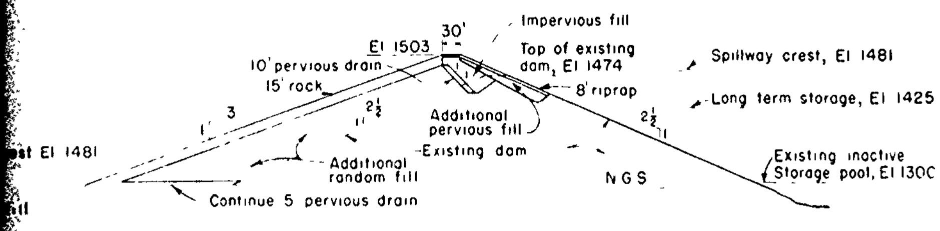


RESERVOIR AREA AND CAPACITY CURVES

LEGEND

- Reservoir at El 1481
- Long Term Storage El 1425
- Existing Stream
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Land Acquisition for Recreation Development
- Outline of Existing Structure

Note Topographic data from field surveys by Philadelphia District in 1954



SECTION - RAISED DAM

100 0 100 200 FEET

REVIEW REPORT DELAWARE RIVER BASIN

BEAR CREEK PROJECT WITH DAM RAISED TO EL. 1503

In 1 Sheet — Scale as Shown

Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

Drawer No 223 — File No 29100

25. Beltzville Project

a. Beltzville dam, as proposed, would be located across Pohopoco valley about 0.3 mile upstream from the confluence of Sawmill Run and Pohopoco Creek. This site is approximately four miles east of Lehighton, Pennsylvania. The gross drainage area above this site is 97 square miles. Data on basic dimensions of the project are as follows:

Capacities
Long term, 41,200 ac.-ft., stream bed to elevation 615
Short term, 27,000 ac.-ft., between elevation 615 and elevation 641

Elevations
Top of dam, 658
Spillway crest, 641
Outlet, upstream invert, 497
Stream bed at dam, 496

Areas
Reservoir at elevation 615, 870 acres
Reservoir at elevation 641, 1,310 acres

b. The valley has been cut into hard Devonian bluish-gray shales that dip 25 to 30 degrees to the south, with the valley floor and the right side of the valley generally covered by pre-Wisconsin glacial drift of moderate permeability. On the right (north) bank of the valley bedrock is exposed about 300 feet from the creek, but a drill hole 500 feet farther north revealed a buried valley filled with glacial drift. The left bank of the valley rises steeply with numerous outcrops of the bedrock exposed. Seven drill holes, seven auger borings and one test pit provided data shown on plates 8 and 9.

c. The dam would consist of an earth and rock fill across the valley and extend to the northeast for a total length of 4,500 feet. It would rise 162 feet above the creekbed. Impervious material and shale for this embankment would be obtained from the spillway excavation and borrow areas in vicinity of the upstream end of the spillway channel. Gravel for bedding and drains would come from previously developed pits in the vicinity of Palmerton, about four miles west of the dam site. Streamflows during construction, minimum flows for use of downstream water users and low-level reservoir releases would be passed through a conduit constructed on rock along the right side of the valley. A spillway would be constructed around the right (north) end of the dam where the channel would be in bedrock. Water from the spillway would discharge into Sawmill Run and thence back into Pohopoco Creek.

d. The reservoir created by this dam would extend approximately 7 miles upstream at spillway crest elevation 641.0 and would make it necessary to relocate or improve approximately 4.7 miles of the county road that is now routed through the valley. No railroads or communities are in the reservoir area, and there are no workable mineral deposits, however, sections of two oil lines would have to be relocated and a powerline and waterline would each have to be reinforced where they cross the reservoir.

TABLE U-4
BELTZVILLE PROJECT COST ESTIMATE

Description	Estimated Cost
Lands & Damages	$ 938,000
Relocations	1,164,000
Reservoir Clearing	154,000
Dam & Appurtenant Works	8,320,000
Fish & Wildlife, Mitigation of Losses 1/	-
Access Road	69,000
Recreation 2/	2,474,000
Building, Grounds, Utilities	31,000
Engineering and Design	877,000
Supervision and Administration	973,000
TOTAL PROJECT COST	$15,000,000

1/ Appendix J contains means of mitigating losses to stream fisheries, game habitat, and public hunting expected to be caused by the project. These means include the acquisition of public fishing rights and development of public use facilities along 6.5 miles of trout streams in Carbon or Monroe County, Pennsylvania, and in habitat improvement and public hunting opportunity on 1000 acres of land needed in Monroe or Carbon County, Pennsylvania. The cost required to provide these mitigations is a project cost, and while omitted from the estimate above is taken into account in the economic analyses in Appendix V.

2/ This cost includes engineering, design, supervision, and administration.

TABLE U-4
BELTZVILLE PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and severance, 1030 ac.		l.s.		$ 99,000
Improvements		l.s.		413,000
Resettlement		l.s.		46,000
Easement, 370 ac.		l.s.		12,000
Land and improvements, 110 ac., R.O.W. for spillway		l.s.		176,000
Contingencies, approx. 15%		l.s.		112,000
Acquisition		l.s.		80,000
Total, Lands and Damages				938,000
Relocations				
Highways				
Improve existing secondary hard surface road	mile	$60,000	1.9	114,000
New Bridges for secondary hard surface road	job	l.s.	2	252,000
Relocate secondary hard surface road	mile	90,000	2.8	252,000
Contingencies, 25%				155,000
Subtotal, Highways				773,000
Utilities				
Relocate oil lines	mile	50,000	4.2	210,000
Reinforce existing 36" water line	job	l.s.		66,000
Reservoir crossing for existing 110 kv. line	job	l.s.		14,000
Relocate service pole line	mile	5,000	4.7	23,000
Contingencies, 25%				78,000
Subtotal, Utilities				391,000
Total, Relocations				1,164,000
Engineering and Design				105,000
Supervision and Administration				116,000

TABLE U-4
BELTZVILLE PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing				
Agricultural land	acre	$ 50	250	$ 12,000
Recreation land	acre	80	80	6,000
Wooded (medium)	acre	210	400	84,000
Bottom land	acre	50	240	12,000
Existing low water	acre	-	60	-
Residential building	each	75	18	1,000
Farm units	each	500	13	7,000
Commercial building	each	300	3	1,000
Contingencies, 25%				31,000
Total, Reservoir Clearing				154,000
Engineering and Design				14,000
Supervision and Administration				15,000
Dam and Appurtenant Works				
Embankment				
Clearing & Grubbing	acre	$ 600.00	35	21,000
Diversion & Care of stream	l.s.	-	-	50,000
Stripping for dam	c.y.	0.80	112,600	90,000
Excavation, cutoff trench	c.y.	0.90	60,000	54,000
Excavation, rock borrow	c.y.	2.00	700,000	1,400,000
Excavation, imperv. borrow	c.y.	0.65	240,000	156,000
Impervious Fill, compacted	c.y.	0.30	745,900	224,000
Rock Fill, compacted	c.y.	0.40	1,680,000	672,000
Filter material, processed	c.y.	4.00	181,800	727,000
Bedding material	c.y.	1.60	73,300	117,000
Additional compaction	hours	15.00	600	9,000
Drilling & pressure grouting	l.f.	9.00	9,400	85,000
Service road	mile	65,000	.83	54,000
Guard rail	l.f.	3.00	8,700	26,000
Riprap	c.y.	4.00	49,000	196,000
Contingencies, 20%				776,000
Subtotal, Embankment				4,657,000

TABLE U-4
BELTZVILLE PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works, Cont'd.				
Outlet Works				
Excavation, common	c.y.	$ 0.60	30,000	$ 18,000
Excavation, rock	c.y.	2.50	2,400	6,000
Close line drilling	s.f.	4.00	9,000	36,000
Drilling & pressure grouting	l.f.	9.00	5,400	49,000
Drilling & grouting anchors	l.f.	10.00	800	8,000
Backfill, conduit	c.y.	1.20	10,000	12,000
Concrete, conduit	c.y.	60.00	3,700	222,000
Concrete, stilling basin	c.y.	50.00	600	30,000
Concrete, intake substructure	c.y.	58.00	3,000	174,000
Concrete, intake tower	c.y.	110.00	900	99,000
Cement	bbls.	6.00	12,000	72,000
Reinforcing steel	lbs.	0.20	350,000	70,000
Miscellaneous metal	lbs.	0.60	50,000	30,000
Foundation preparation	s.y.	7.00	2,000	14,000
Water stops	l.f.	3.00	3,000	9,000
Service bridge	s.f.	40.00	4,600	184,000
Operating house superstructure	l.s.	-	-	25,000
Spiral stairway	l.s.	-	-	5,000
Sluice gates	lbs.	0.60	175,000	105,000
Gate operating sys.	l.s.	-	-	12,000
By pass system	l.s.	-	-	8,000
Floatwell & drain system	l.s.	-	-	15,000
Lighting & power system	l.s.	-	-	11,000
Heating & ventilating system	l.s.	-	-	6,000
Trolley hoist, 5 ton	l.s.	-	-	9,000
Chain hoist, 1-1/2 ton	l.s.	-	-	1,000
Tile gage	l.s.	-	-	3,000
Contingencies, 20%				247,000
Subtotal, Outlet Works				1,480,000
Spillway				
Clearing & grubbing	acre	600.00	35	21,000
Excavation, common	c.y.	0.60	460,400	276,000
Excavation, rock	c.y.	1.80	782,300	1,410,000
Close line drilling	s.f.	4.00	6,500	26,000
Drilling & pressure grouting	l.f.	9.00	2,000	18,000
Drilling & grouting anchors	l.f.	10.00	500	5,000

TABLE U-4
BELTZVILLE PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works Cont'd.				
Spillway - Continued				
Concrete, sill	c.y.	$ 30.00	400	$ 12,000
Concrete training wall	c.y.	60.00	550	33,000
Cement	bbls.	6.00	1,000	6,000
Reinforcing steel	lbs.	0.20	40,000	8,000
Backfill	c.y.	2.00	1,500	3,000
Guard rail	l.f.	4.00	250	1,000
Contingencies, 20%				364,000
Subtotal, Spillway				2,183,000
Total, Dam and Appurtenant Works				8,320,000
Engineering and Design				749,000
Supervision and Administration				832,000
Access Road				
New road	mile	110,000	0.5	55,000
Contingencies, 25%				14,000
Total, Access Road				69,000
Engineering and Design				6,000
Supervision and Administration				7,000
Recreation				
Facilities 1/	job	l.s.	-	2,029,000
Real Estate, 1,383 ac.	"	"	-	445,000
Total, Recreation				2,474,000

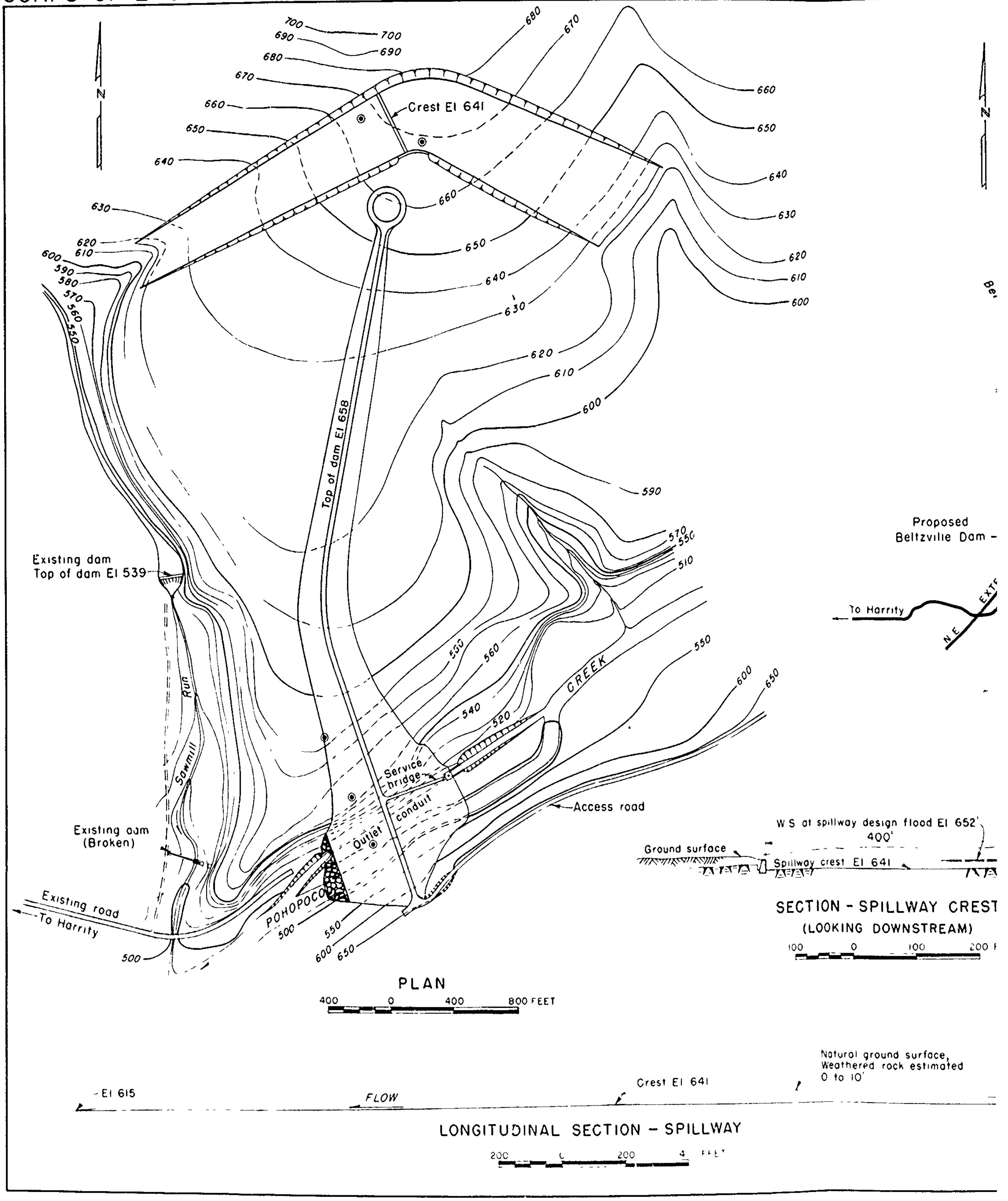
1/ Includes engineering, design, supervision and administration.

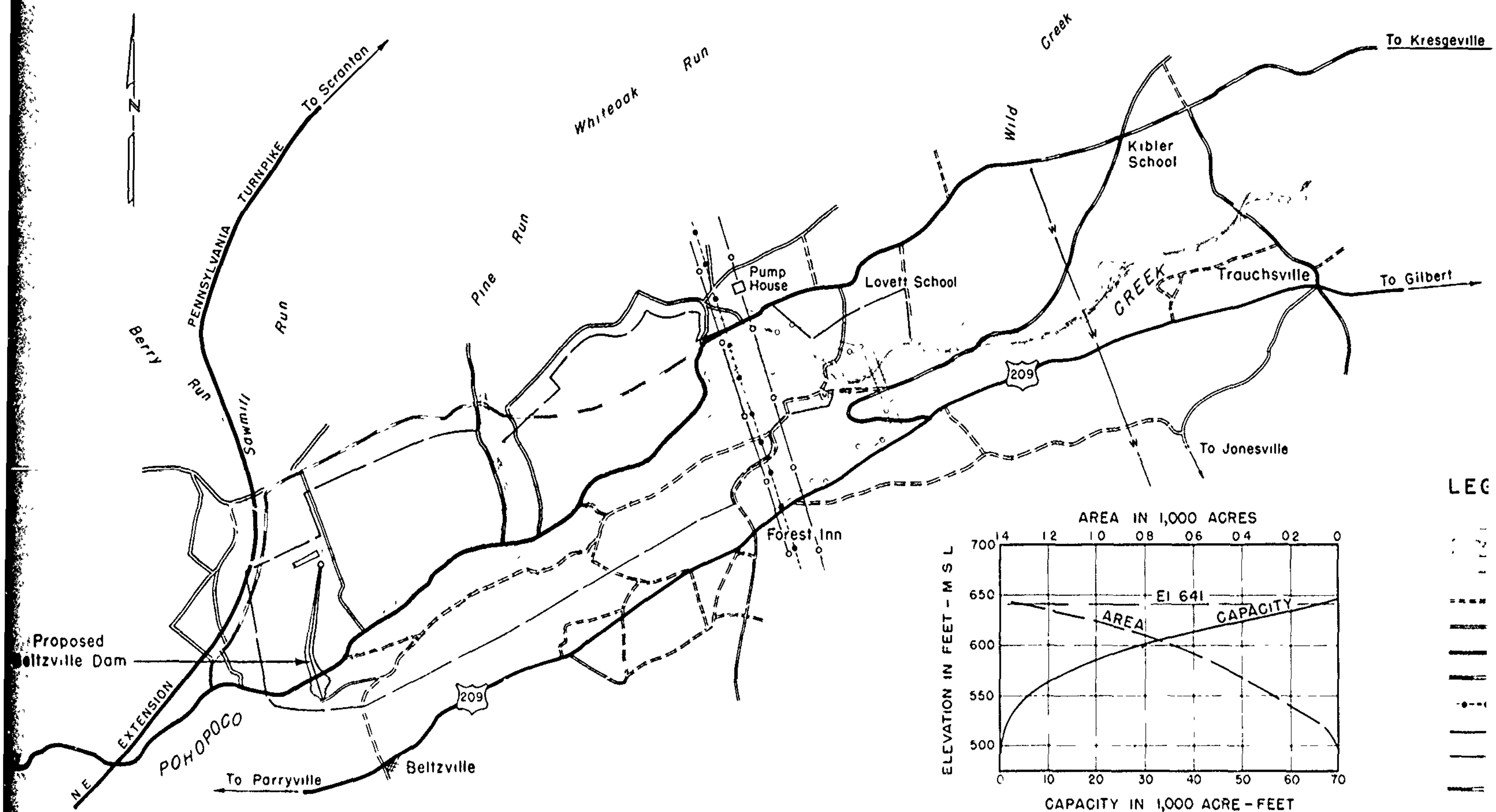
(Rev. Nov. 1960)

TABLE U-4
BELTZVILLE PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Buildings, Grounds and Utilities				
Administration, maintenance building, etc.	job	l.s.		$ 25,000
Contingencies, 25%				6,000
Total, Buildings, Grounds and Utilities				31,000
Engineering and Design				3,000
Supervision and Administration				3,000

CORPS OF ENGINEERS



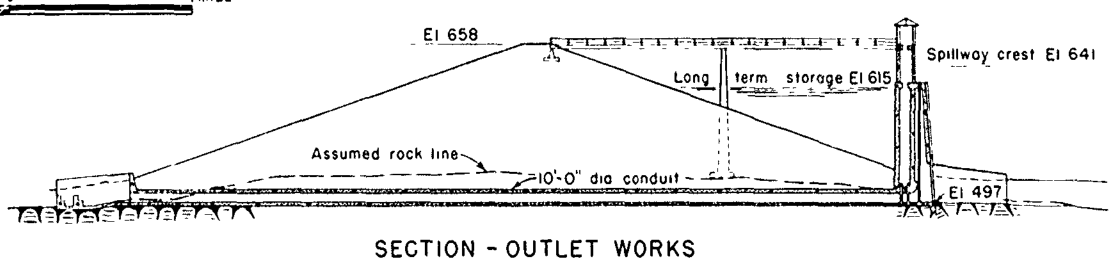


RESERVOIR MAP

1 0 1 MILE

RESERVOIR AREA AND CAPACITY CURVES

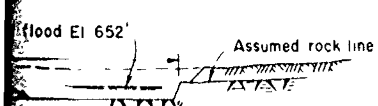
LEG



SECTION - OUTLET WORKS

100 0 100 200 FEET

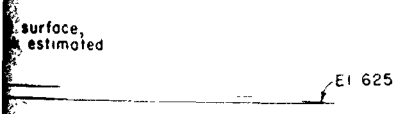
Note
Geol
sect

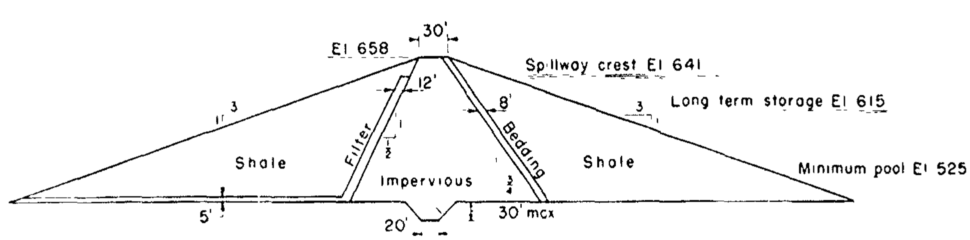


LWAY CREST
NSTREAM)

100 200 FEET

RI





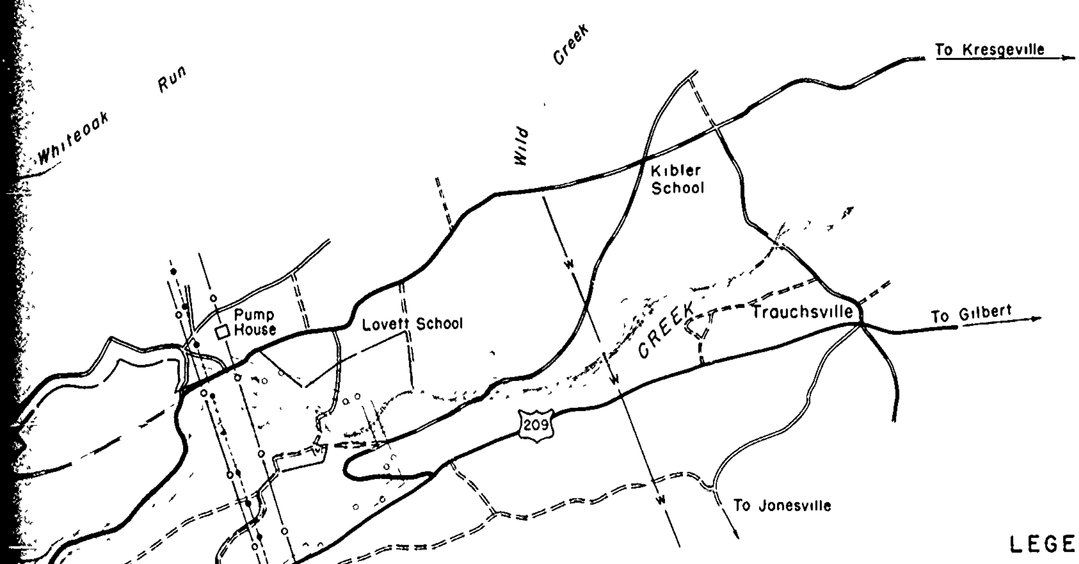
TYPICAL SECTION - DAM

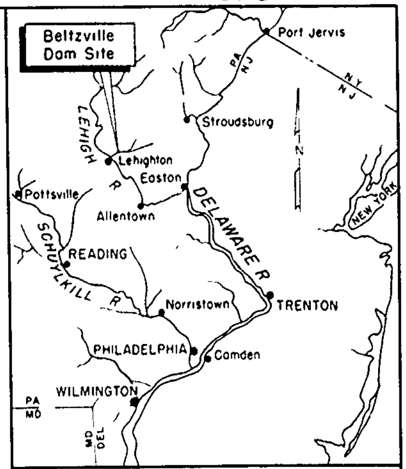
100 0 100 200 FEET

In I S

Corps
Philad

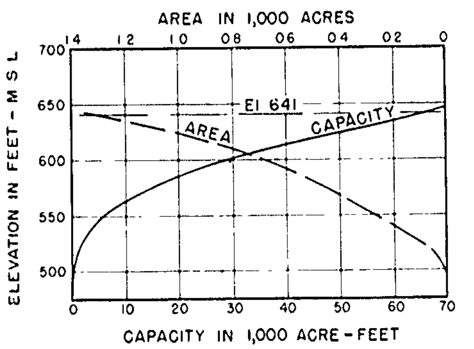
Drawer





LOCATION MAP

SCALE

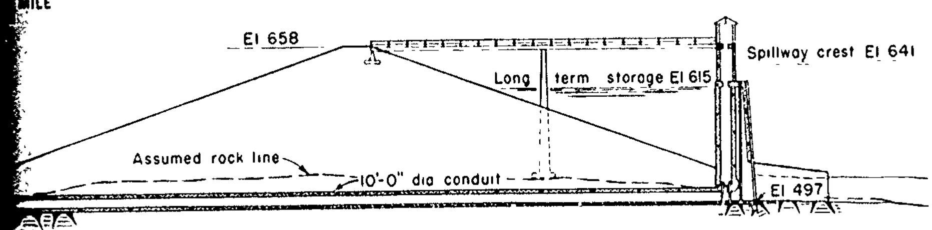


RESERVOIR AREA AND CAPACITY CURVES

LEGEND

- Reservoir at El 641
- Long Term Storage El 615
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Power Line
- Existing Oil Line
- Existing Water Line
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Power Line
- Proposed Relocated Oil Line
- Land Acquisition for Recreation Development
- Drill Hole

Note Topography at dam site taken from U S Geological Survey maps modified by cross sections obtained in field

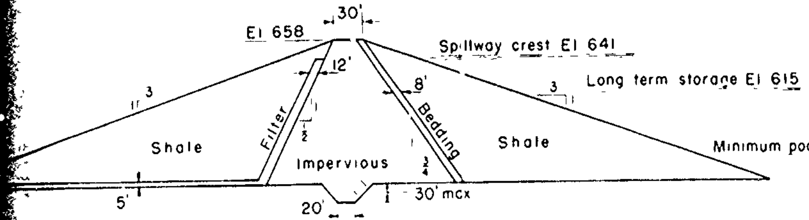


SECTION - OUTLET WORKS

100 0 100 200 FEET

REVIEW REPORT DELAWARE RIVER BASIN

BELTZVILLE PROJECT



TYPICAL SECTION - DAM

100 0 100 200 FEET

In 1 Sheet

Scale as Shown

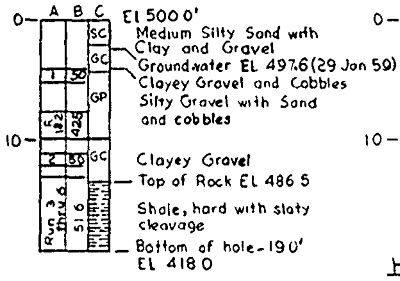
Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960
Revised Nov 1960

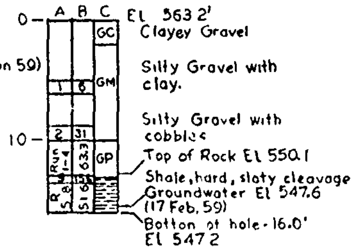
Drawer No 228

File No 29095

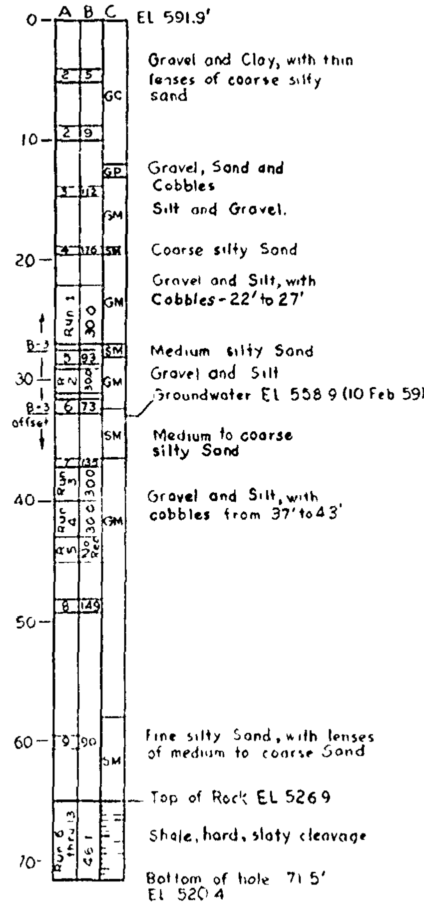
CORPS OF ENGINEERS



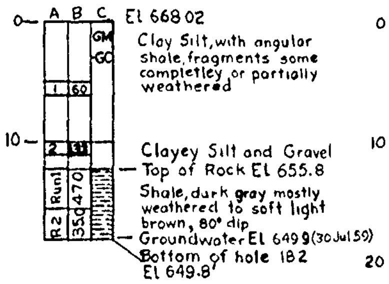
HOLE B-1



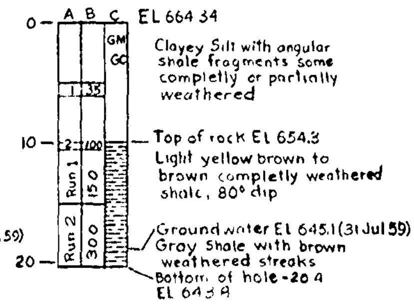
HOLE B-2



HOLE B-3 and B-3 offset



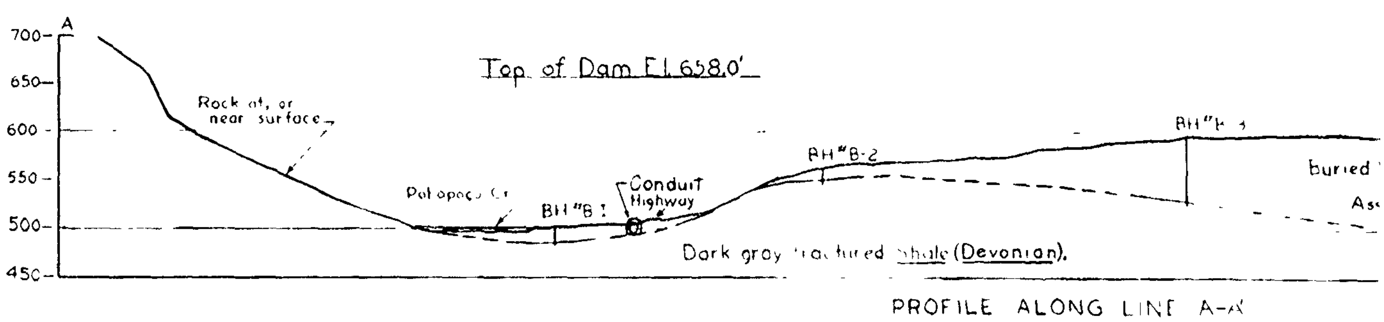
HOLE B-4



HOLE B-5

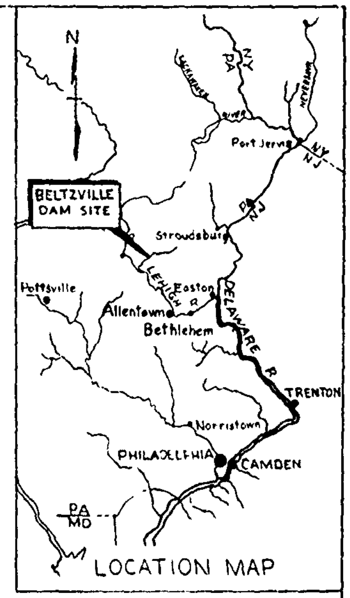
NOTES

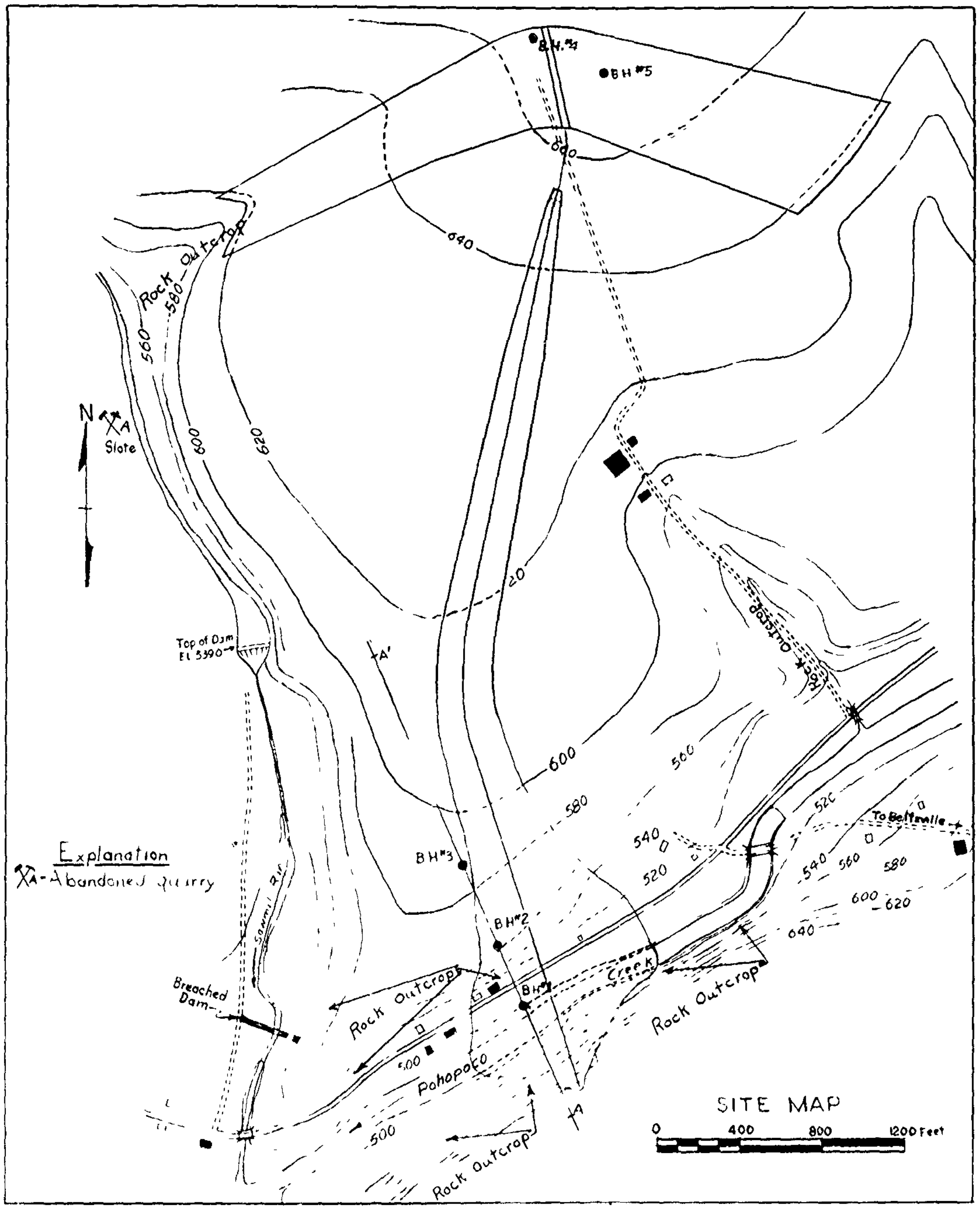
1. Descriptions of materials encountered in borings are based on visual inspection of spoon and core samples
2. Column "A" refers to the sample number or core run number
3. Column "B" refers to (a) the number of blows of a 140 lb hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered, or (b) the amount of core recovery, stated in percent, of a specified run of core barrel
4. Column "C" is a visual classification of the materials encountered, designated by letter symbol using the Unified Soils Classification System and graphic rock symbols.
5. All elevations based on mean sea level datum
6. Hole #3 offset located three feet west of hole #3
7. Borings 1, 2 and 3 by US Testing Co, Phila, Pa, Jan, Feb, 1959
8. Borings 4 and 5 by U S Corps of engineers, Phila Dist, July, 1959

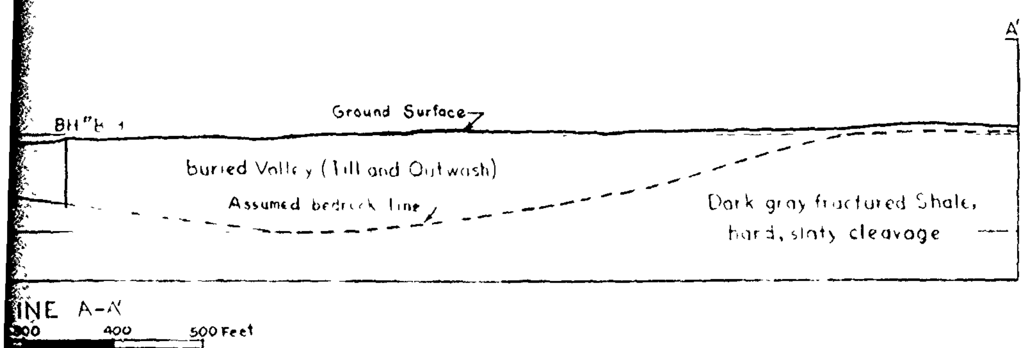


PROFILE ALONG LINE A-A'

U.S ARMY







REVIEW REPORT DELAWARE RIVER BASIN

BELTZVILLE PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

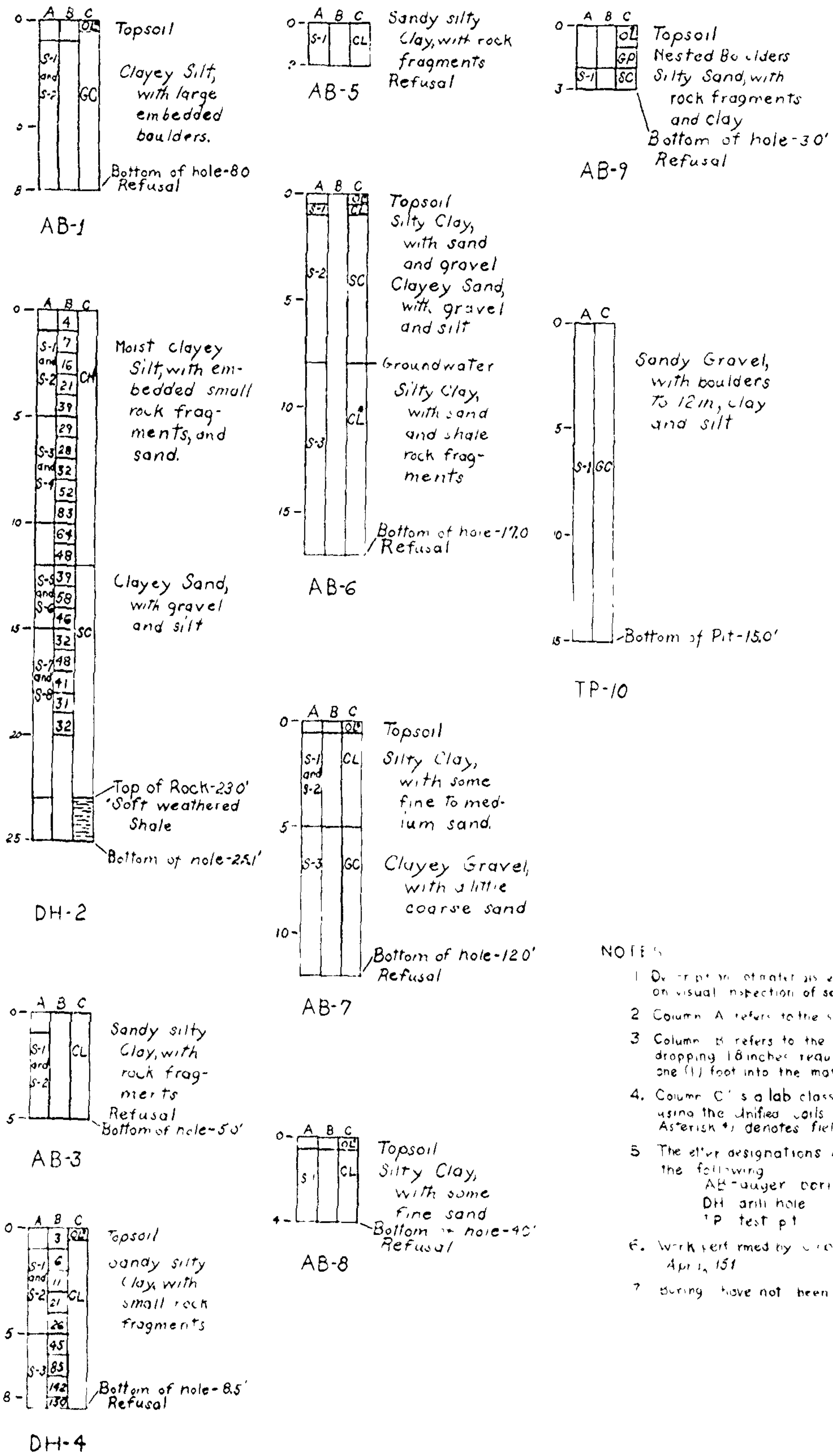
Scales as Shown
Philadelphia District
13 Jan 60

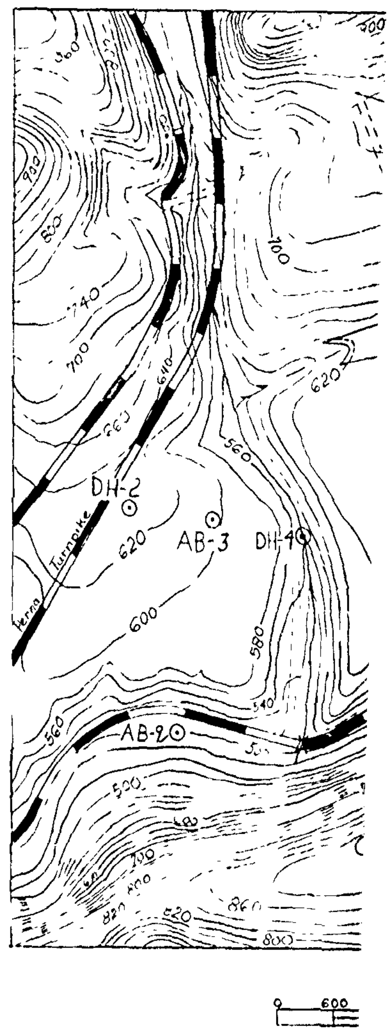
Drawer No 228

File No 28915

PLATE 8

CORPS OF ENGINEERS





NOTES

1. Description of materials encountered in borings are based on visual inspection of samples
2. Column A refers to the sample number
3. Column B refers to the number of blows a 300 lb hammer dropping 18 inches required to push the sampling spoon one (1) foot into the material encountered
4. Column C is a lab classification of the materials encountered, using the Unified Soils Classification System symbols. Asterisk (*) denotes field or visual classification
5. The letter designations at the bottom of each log stand for the following
   - AB - auger boring
   - DH - drill hole
   - TP - test pit
6. Work performed by Corps of Engineers Baltimore Dist, April, 1951
7. Borings have not been surveyed, locations only approximate

A	B	C	
		OL	Topsoil
		GP	Nested Boulders
S-1		SC	Silty Sand, with rock fragments and clay

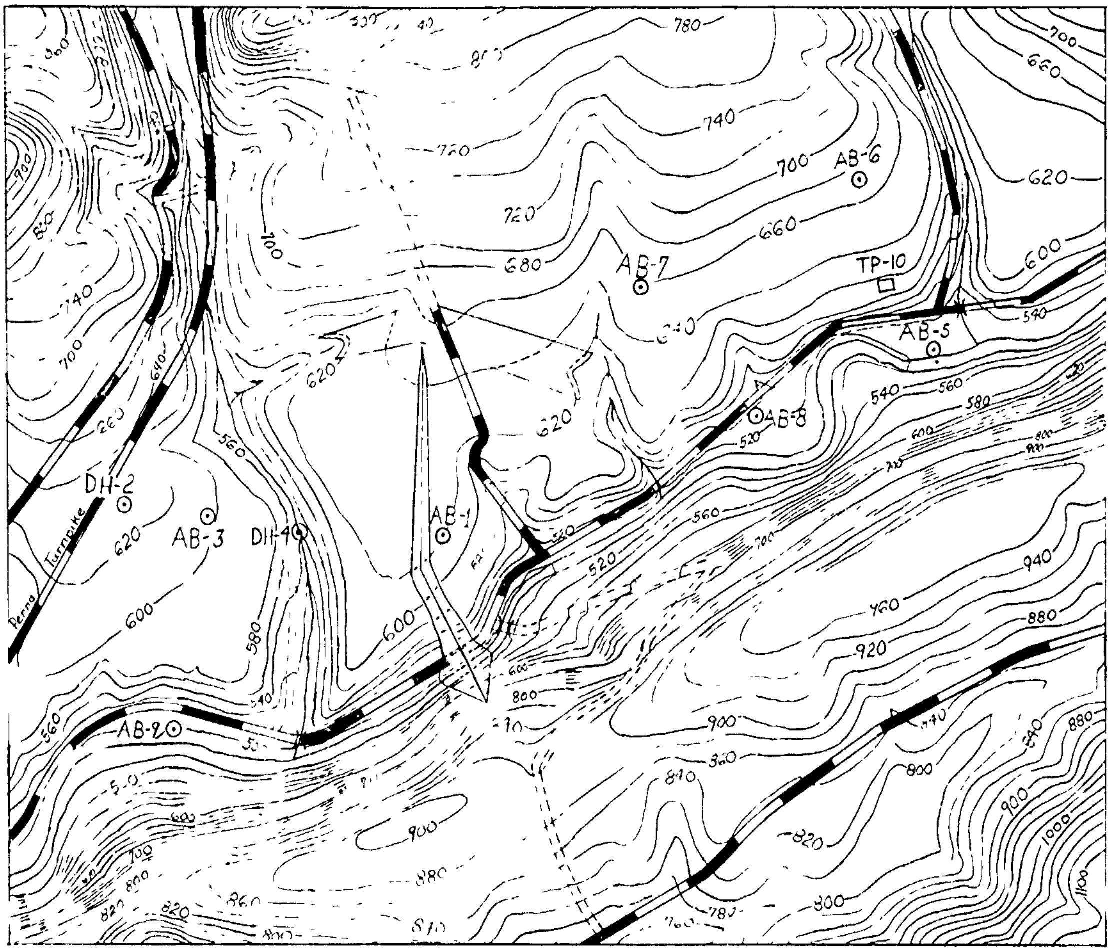
Bottom of hole - 3.0'
Refusal

AB-9

A	C	
S-1	GC	Sandy Gravel, with boulders to 12 in., clay and silt

Bottom of Pit - 15.0'

TP-10



SITE MAP

0 600 1500 3000 6000 FT.

NOTE:

1. Description of material encountered in borings are based on visual inspection of samples.
2. Column A refers to the sample number.
3. Column B refers to the number of blows of a 300 lb hammer dropping 18 inches required to push the sampling spoon one (1) foot into the materials encountered.
4. Column C is a lab classification of the materials encountered, using the Unified Soils Classification System symbols. Asterisk (*) denotes field or visual classification.
5. The letter designations at the bottom of each log stand for the following:
   - AB - auger boring
   - DH - drill hole
   - TP - test pit
6. Work performed by ... of Engineers Baltimore Dist, April 1951
7. Borings have not been surveyed, locations only approximate.

REVIEW REPORT DELAWARE RIVER BASIN

BELTZVILLE PROJECT
BORROW INVESTIGATIONS

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
16 Nov 59

Drawer No 228

File No 29079

26. Blue Marsh Project

a. Blue Marsh dam, as proposed, would be located across Tulpehocken Creek 1-1/2 miles upstream from the mouth of Plum Creek and about 6 miles northwest of Reading, Pennsylvania. The drainage area above this site is 175 square miles. Data on basic dimensions of the project are as follows:

Capacities

Long term, 16,000 ac.-ft., stream bed to elevation 279
Short term,33,000 ac.-ft., between elevation 279 and elevation 303

Elevations

Top of dam, 320
Spillway crest, 303
Outlet, upstream invert, 230
Stream bed at dam, 230

Areas

Reservoir at elevation 279, 870 acres
Reservoir at elevation 303, 2,020 acres

b. Tulpehocken Creek, at the dam site, has eroded a valley in Ordovician Martinsburg shale about 500 feet wide, rising steeply on both banks. Shale, exposed in both abutments, is undoubtedly present in the valley floor covered by a thin layer of alluvial deposits. The steep dip of the shale gives it increased resistance to erosion; and, except for thin calcite veins and a small carbonate content, it is very insoluble. Two borings were made in the left (east) rim of the reservoir near the dam site to determine the extent of a westward plunging anticline of limestone which is exposed about 1,000 feet east of the reservoir. The indications are that the limestone bed does not penetrate to the reservoir and hence would not be exposed to reservoir water. A third boring was made about 3/4 of a mile northwest of the first two borings where two small limestone quarries exist in the left bank of the creek. This limestone lens disappears midway between Tulpehocken and Plum Creeks. Boring and geologic data are shown on plate 11. Provision has been made in the cost estimate for the reservoir for grouting along the east rim in the event more detailed investigations prove the need.

c. The dam would consist of a rock and earth fill embankment 1,100 feet long by 90 feet high, built of material taken from excavation for the spillway and borrow areas, for impervious material, in the valley near the dam. A conduit on rock along the right abutment would provide for reservoir releases and diversion. The spillway would be located about 1,000 feet south of the dam where a 900-foot wide flat-crested channel cut into the shale would conduct water from the reservoir to Tulpehocken Creek.

d. The reservoir created by this dam would extend upstream about 10 miles on Tulpehocken and Northkill Creeks when the pool is at spillway crest elevation 303. This reservoir would not inundate any railroads but would make it necessary to move pipe lines, roads, the community of Blue Marsh and a few buildings in Bernville. An amount is included in the estimates for two small pumping units and storm water sewers to aid drainage for Bernville during floods. The estimates include the cost of purchasing the only commercially valuable mineral deposit in the reservoir -- a shale pit about one mile north of Blue Marsh which is operated as the source of supply for a brick plant.

TABLE U-5
BLUE MARSH PROJECT COST ESTIMATE

Description	Estimated Cost
Lands & Damages	$ 3,100,000
Relocations	1,848,000
Reservoir Clearing	331,000
Dam & Appurtenant Works	4,406,000
Fish & Wildlife Mitigations 1/	-
Access Road	30,000
Recreation 2/	4,782,000
Buildings, Grounds, Utilities	31,000
Engineering and Design	599,000
Supervision and Administration	665,000
TOTAL PROJECT COST	$15,792,000

1/ Information regarding the acquisition of land and streams relative to recovery of fish and wild life losses comparable to that given for the Aquashicola project has not been received.
2/ This cost includes engineering, design, supervision, and administration.

TABLE U-5
BLUE MARSH PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and severance 1520 ac	job	l.s.	-	$ 536,000
Improvements, 174 units	job	l.s.	-	1,543,000
Resettlement, 174 units	job	l.s.	-	78,000
Easement, 700 ac with improvements	job	l.s.	-	362,000
R.O.W. for drainage pumps near Bernville	job	l.s.	-	43,000
Contingencies, Approx.15%				384,000
Acquisition				154,000
Total cost - Land and Damages				3,100,000
Relocations				
Highways				
Improve existing State Road No. 83	mile	$100,000	1.7	170,000
Relocate primary hard surface road	mile	150,000	0.4	60,000
New bridge for primary hard surface road	job	l.s.	-	192,000
Improve existing secondary hard surface road	mile	75,000	0.4	30,000
Relocate graded road	mile	50,000	3.0	150,000
New bridges (2) for graded road	job	l.s.	-	276,000
Contingencies, 25%				220,000
Subtotal, Highways				1,098,000
Utilities				
Relocate petroleum lines	mile	70,000	7.5	525,000
Relocate gas line	mile	75,000	0.8	60,000
Relocate service pole line	mile	6,000	2.5	15,000
Contingencies, 25%				150,000
Subtotal, Utilities				750,000
Total Cost - Relocations				$1,848,000
Engineering and Design				166,000
Supervision and Administration				165,000

TABLE U-5
BLUE MARSH PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir				
Clearing				
Agricultural land	acre	$ 80	1,105	$ 88,000
Residential and recreational land	acre	50	165	8,000
Shale Pit	acre	0	150	0
Creek Bed	acre	0	100	0
Farm Units	each	500	47	23,000
Residences	each	75	70	5,000
Summer Cottages	each	50	79	4,000
Commercial	each	400	5	2,000
Dikes near dam	job	l.s.		16,000
Grouting Reservoir Rim	job	l.s.		60,000
Pumping plants near Bernville	job	l.s.		59,000
Contingencies, 25%	job	l.s.		66,000
Total Cost, Reservoir Clearing & Dikes				331,000
Engineering and Design				30,000
Supervision and Administration				33,000
Dam and Appurtenant Works				
Embankment				
Clearing and Grubbing	acre	600	42	25,000
Diversion & Care of River	job	l.s.		50,000
Stripping for Dam	c.y.	0.80	21,500	17,000
Excavation, Cutoff Trench	c.y.	1.00	5,000	5,000
Foundation Preparation	s.y.	7.00	2,100	15,000
Impervious Fill	c.y.	0.30	60,000	18,000
Random Fill	c.y.	0.40	637,000	255,000
Filter Material, processed	c.y.	5.00	77,000	385,000
Riprap, quarried	c.y.	5.00	11,400	57,000
Excavation, impervious borrow	c.y.	0.75	69,000	52,000
Drilling and Pressure Grouting	l.f.	9.00	5,000	45,000
Additional Compaction	r.h.	15.00	500	7,000
Service Road	mile	50,000.00	0.35	18,000
Guardrail	l.f.	3.00	3,400	10,000
Contingencies				174,000
Subtotal, embankment				1,133,000

(Rev Oct. 1960)

TABLE U-5
BLUE MARSH PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works (cont'd)				
Outlet Works				
Excavation, common	c.y.	$1.00	6,000	$ 6,000
Excavation, rock	c.y.	1.80	11,000	20,000
Foundation preparation	s.y.	7.00	1,000	7,000
Backfill	c.y.	2.00	5,000	10,000
Concrete, conduit	c.y.	60.00	2,900	174,000
Concrete, intake sub-structure	c.y.	60.00	2,100	126,000
Concrete, intake super-structure	c.y.	110.00	600	66,000
Concrete, stilling basin	c.y.	50.00	600	30,000
Backfill	c.y.	2.00	5,000	10,000
Drilling & Pressure Grouting	l.f.	9.00	400	4,000
Foundation Preparation	s.y.	7.00	1,000	7,000
Line Drilling	s.f.	4.00	6,500	26,000
Drilling & Grouting Anchors	l.f.	8.00	500	4,000
Portland Cement	bbl.	6.00	9,000	54,000
Reinforcing Steel	lb.	0.20	310,000	62,000
Water Stops	l.f.	3.00	3,200	10,000
Service Bridge	s.f.	40.00	2,700	108,000
Miscellaneous Metal	lb.	0.60	35,000	21,000
Operating House Super-structure	job	l.s.	-	25,000
Spiral Stairway	job	-	-	4,000
Sluice Gates (2)	lb.	0.60	150,000	90,000
Gate Operating System	job	l.s.	-	12,000
Bypass System	job	l.s.	-	15,000
Floatwell & Drain System	job	l.s.	-	14,000
Lighting & Power System	job	l.s.	-	11,000
Heating & Ventilating System	job	l.s.	-	6,000
Trolley Hoist, 5 ton	job	l.s.	-	9,000
Chain Hoist, 1-1/2 Ton	job	l.s.	-	1,000
Tile Gage	job	l.s.	-	2,000
Contingencies, 20%				187,000
Subtotal, Outlet Works				1,121,000
Spillway				
Excavation, common	c.y.	0.60	250,000	150,000
Excavation, rock	c.y.	1.80	855,000	1,539,000
Concrete, sill	c.y.	30.00	900	27,000
Line Drilling	s.f.	4.00	7,000	28,000
Foundation Preparation	s.y.	7.00	600	4,000
Drilling & Pressure Grouting	l.f.	9.00	4,000	36,000
Guard Rail	l.f.	3.00	1,000	3,000

TABLE U-5

BLUE MARSH PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works (Contd)				
Spillway (contd)				
Cement	bbl.	$ 6.00	1,000	$ 6,000
Contingencies, 20%				359,000
Subtotal, spillway				2,152,000
Total Cost, Dam and Appurtenances				4,406,000
Engineering and Design				397,000
Supervision and Administration				441,000
Access Road				
New Road	mile	24,000	1	24,000
Contingencies, 25%				6,000
Total Cost, Access Road				30,000
Engineering and Design				3,000
Supervision and Administration				3,000
Recreation				
Facilities[1/]	job	L.S.		2,075,000
Real Estate, 3,776 acres	job	L.S.		2,707,000
Total Cost, Recreation				4,782,000

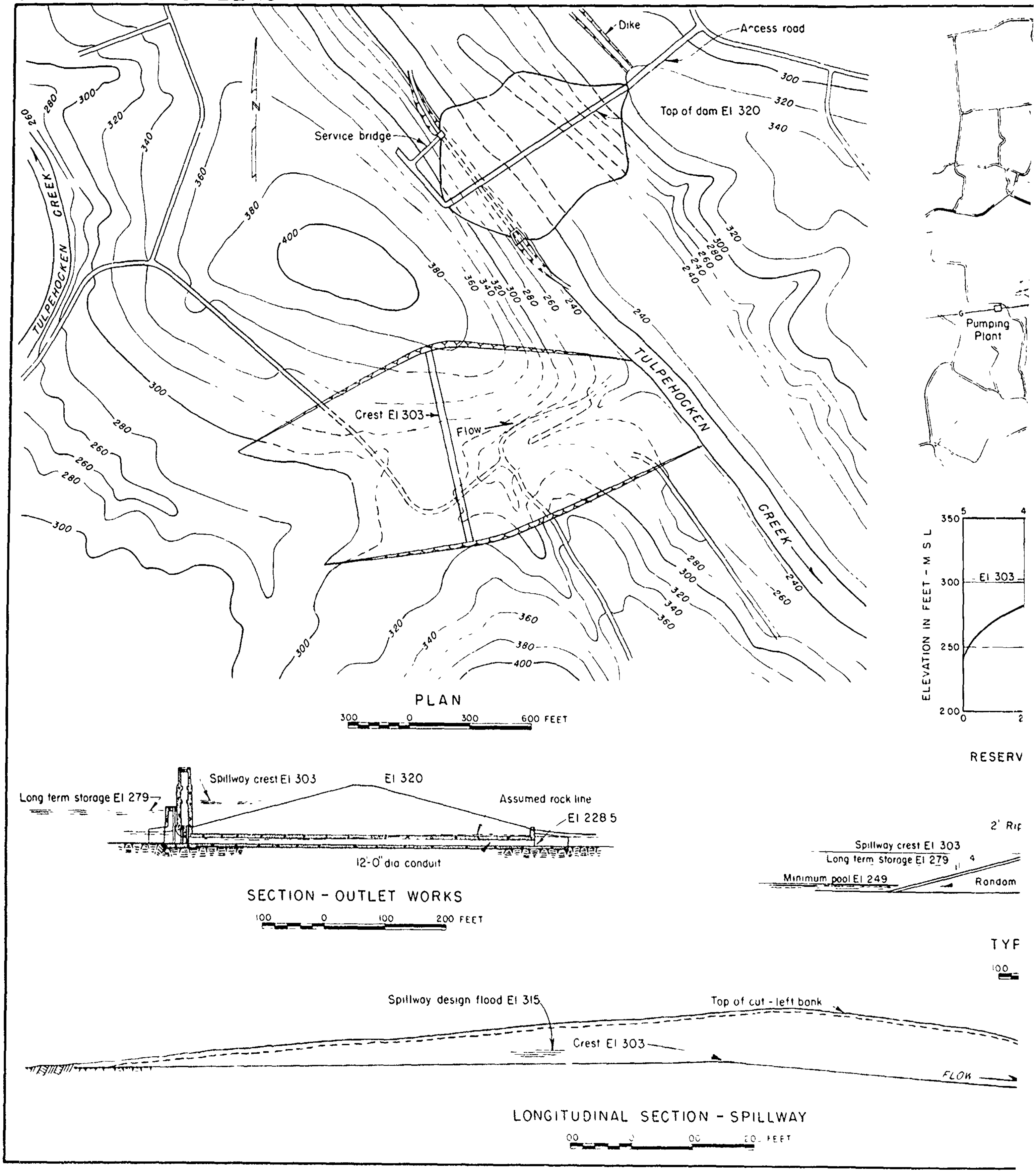
1/ Includes engineering, design, supervision and administration.

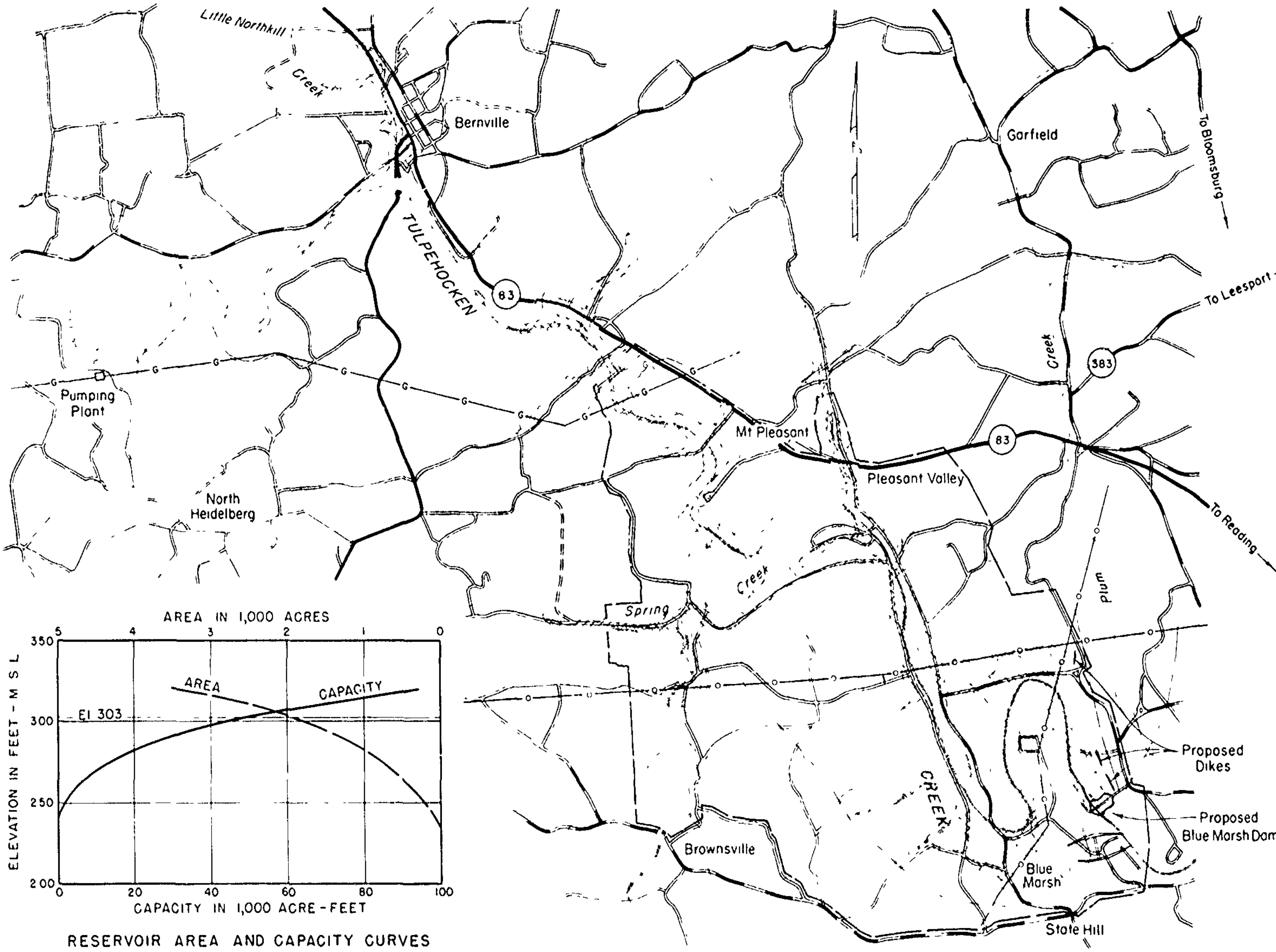
TABLE U-5

BLUE MARSH PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Building, Grounds, Utilities				
Administration, Maintenance Building, etc.	job	l.s.	-	$ 25,000
Contingencies, 25%				6,000
Total, Building, Grounds, Utilities				31,000
Engineering and Design				3,000
Supervision and Administration				3,000

CORPS OF ENGINEERS

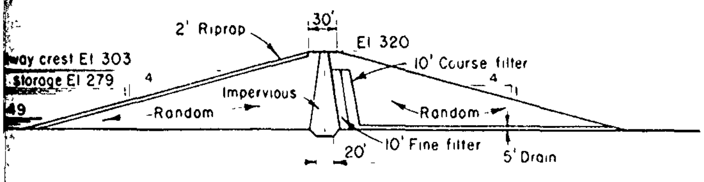




RESERVOIR AREA AND CAPACITY CURVES

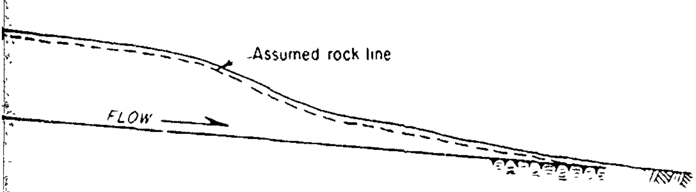
RESERVOIR MAP

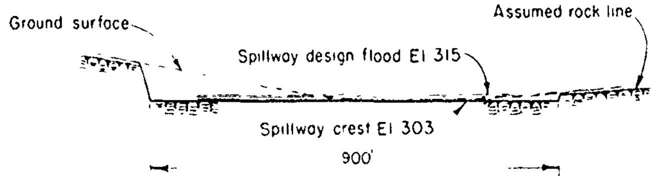
1 ½ 0 1 MILE



TYPICAL SECTION - DAM

100 0 100 200 FEET





SECTION - SPILLWAY CREST
(LOOKING DOWNSTREAM)

200 0 200 400 FEET

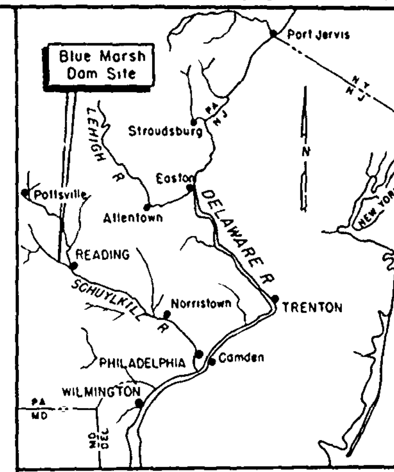
LEG

R1

In I St

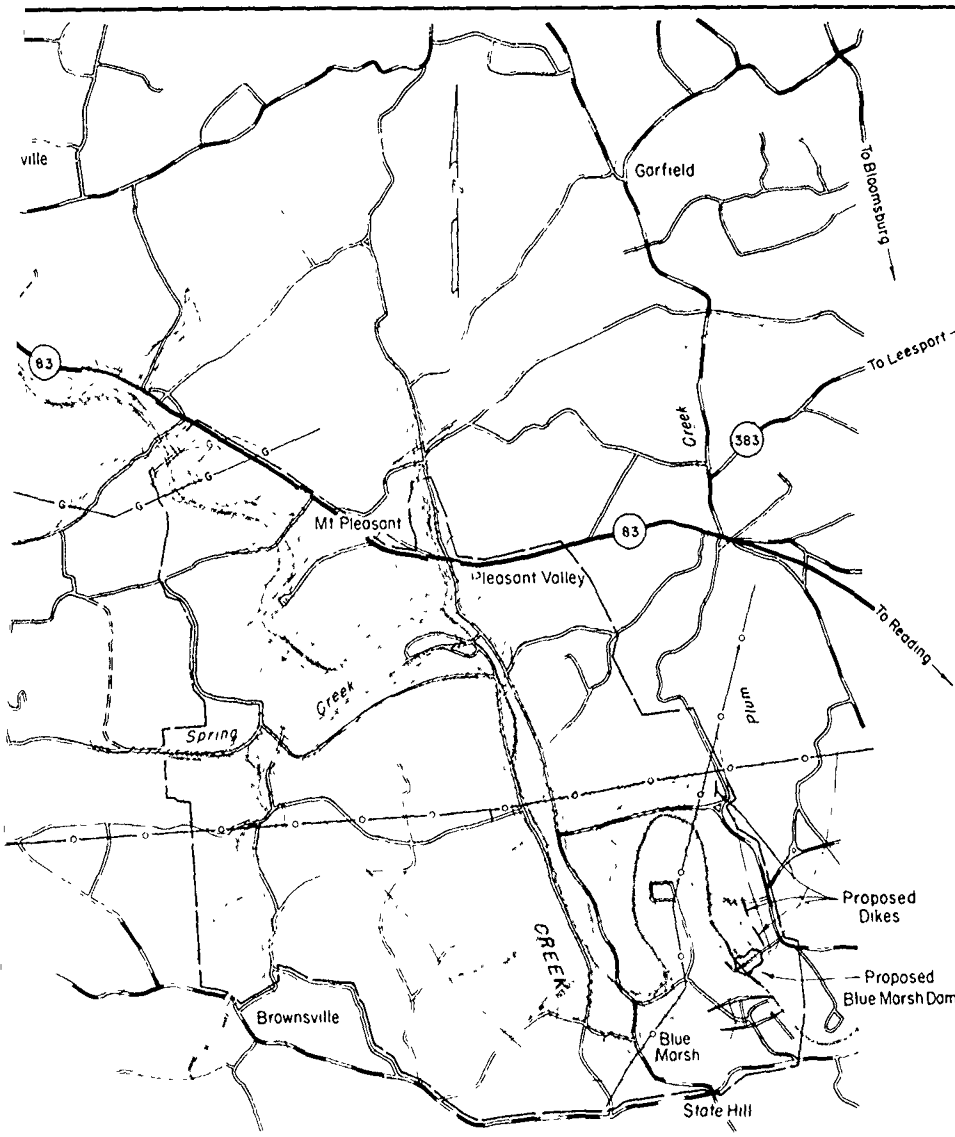
Corps
Philad

Drawer



LOCATION MAP

SCALE

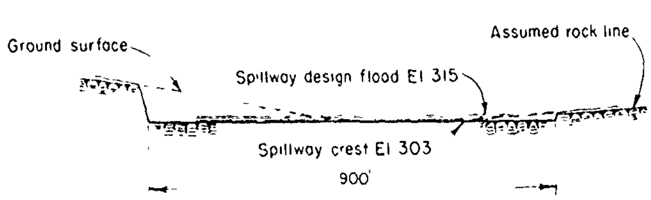


LEGEND

- Reservoir at El 303
- Long Term Storage El 279
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Gas Pipe Line
- Existing Oil Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Gas Pipe Line
- Proposed Relocated Oil Line
- Land Acquisition for Recreation Development

RESERVOIR MAP

1 ½ 0 1 MILE



SECTION - SPILLWAY CREST
(LOOKING DOWNSTREAM)

200 0 200 400 FEET

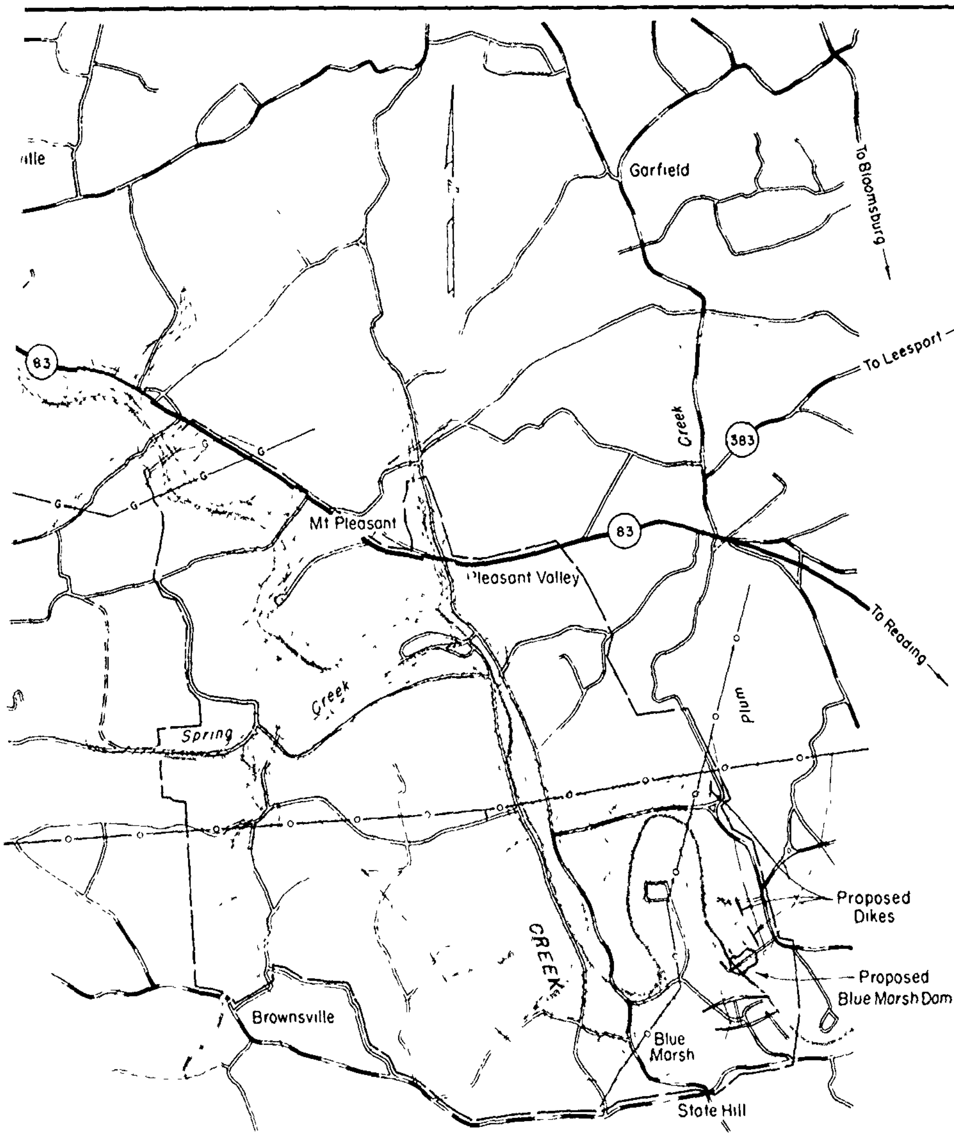
REVIEW REPORT DELAWARE RIVER BASIN

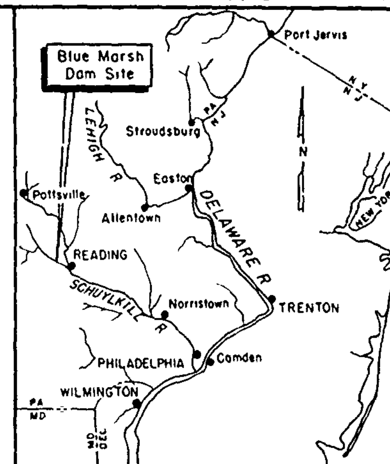
BLUE MARSH PROJECT

In 1 Sheet — Scale as Shown

Corps of Engineers, Philadelphia, Pa — Philadelphia District, June 1960

Drawer No 228 — File No 29096





LOCATION MAP

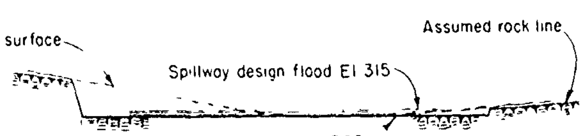
SCALE

LEGEND

- Reservoir at El 303
- Long Term Storage El 279
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Gas Pipe Line
- Existing Oil Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Gas Pipe Line
- Proposed Relocated Oil Line
- Land Acquisition for Recreation Development

RESERVOIR MAP

1 ½ 0 1 MILE



SECTION - SPILLWAY CREST
(LOOKING DOWNSTREAM)

200 0 200 400 FEET

REVIEW REPORT DELAWARE RIVER BASIN

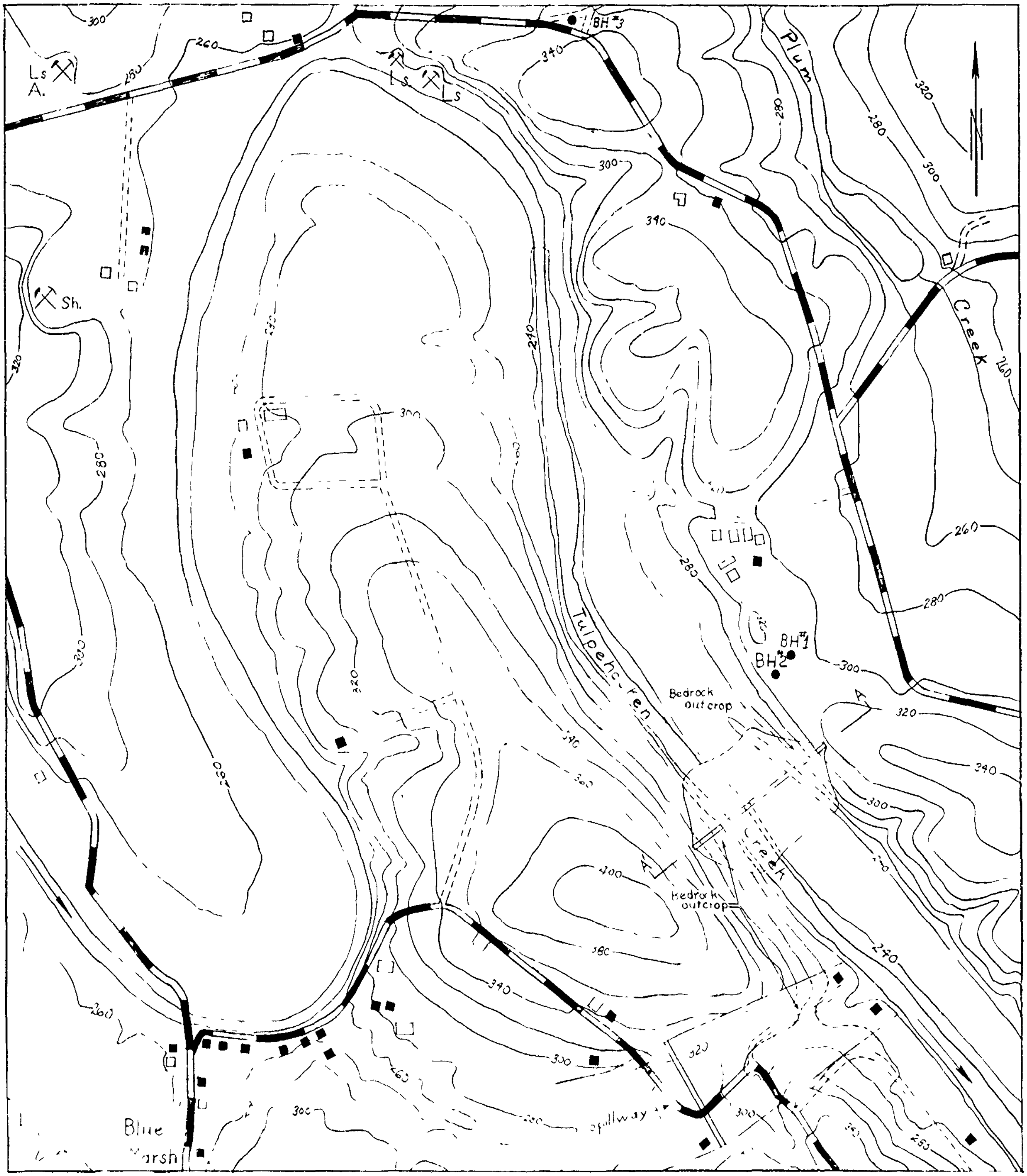
BLUE MARSH PROJECT

In 1 Sheet | Scale as Shown

Corps of Engineers
Philadelphia, Pa

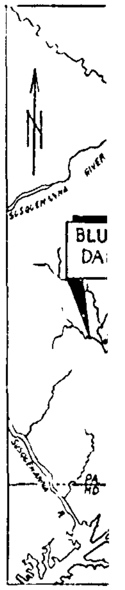
Philadelphia District
June 1960

Drawer No 228 | File No 29096



SITE MAP

0 200 500 1000 2000 FT



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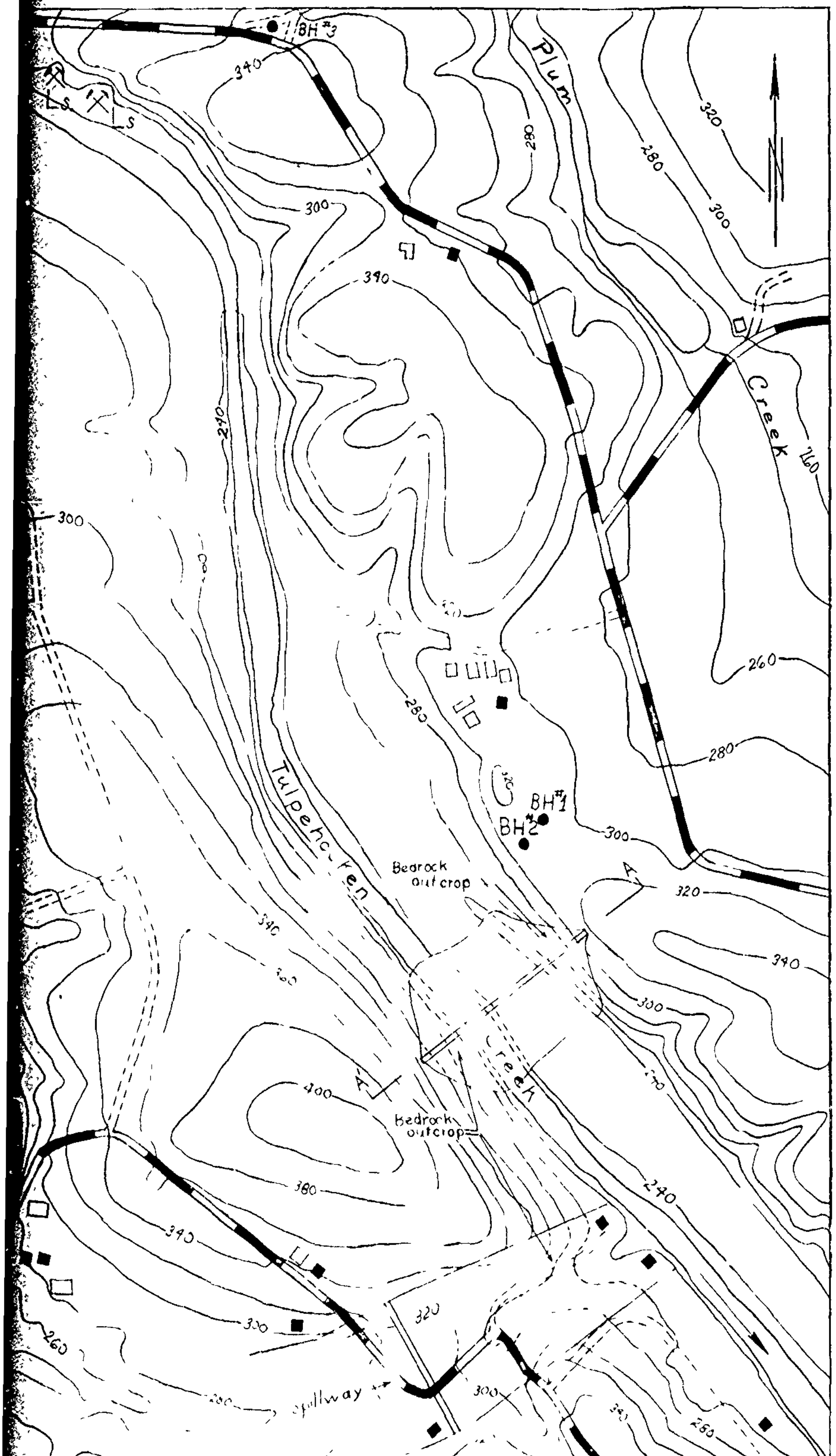
Sheet
Corps of Engineers
Philadelphia, Pa

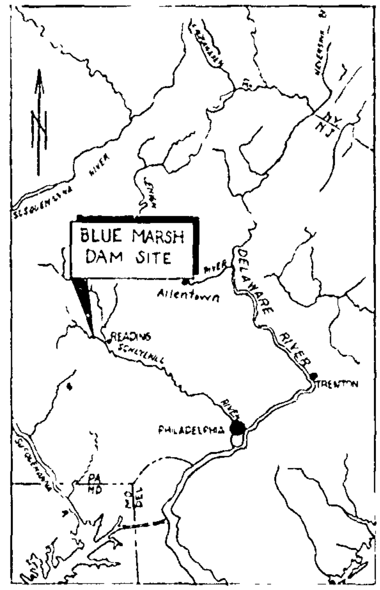
Drawer No 228

U. S. ARMY

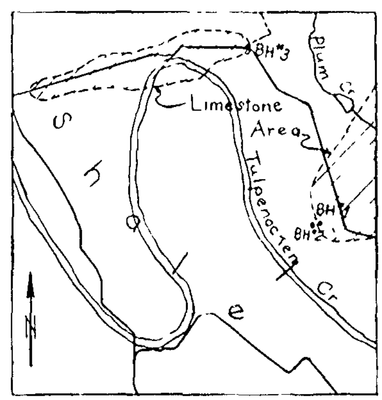


SITE MAP

200 500 1000 2000 FT



LOCATION MAP



GEOLOGIC MAP

0 1000 2000 3000 FT

REVIEW REPORT DELAWARE RIVER BASIN

BLUE MARSH PROJECT
GEOLOGIC DATA

In Sheet Corps of Engineers Philadelphia, Pa	Scales as Shown Philadelphia District 12 Jan 60
Drawer No 228	File No 2°081

PLATE II

27. Maiden Creek Project

a. Maiden Creek dam, as proposed, would be located across the valley of Maiden Creek about 1/3 mile upstream from the mouth of Moselem Creek and about 12 miles north of Reading, Pennsylvania. At this location there are 161 square miles of drainage upstream from the site. Data on basic dimensions of the project are as follows:

Capacities
- Long term, 76,000 ac.-ft., stream bed to elevation 381
- Short term, 38,000 ac.-ft., between elevation 381 and elevation 394

Elevations
- Top of dam, 412
- Spillway crest, 394
- Outlet, upstream invert, 304
- Stream bed at dam, 300

Areas
- Reservoir at elevation 381, 2,500 acres
- Reservoir at elevation 394, 3,320 acres

b. Maiden Creek, at the dam site, lies along the left side of a flood plain about 800 feet wide. The left (east) abutment rises steeply whereas the right abutment rises more gently. The site is in an area of Ordovician, Martinsburg shale with outcrops in evidence on both abutments. The reservoir area overlies these shales, which contain many interbedded limestone lenses in the part of the reservoir extending from the dam site upstream about three miles. The overburden, consisting of silty clay and slate shards, which varies in thickness from 0 to 15 feet, is impermeable. Two borings made in the flood plain, provided data shown on plate 13.

c. The dam would consist of an earth and rock fill 2,600 feet long rising 112 feet above Maiden Creek. Material will come from spillway excavation and from borrow areas near the dam, located along existing roads in the valley. A conduit founded on rock along the left side of the valley would carry reservoir releases and diversion flows. The spillway, 750 feet wide at elevation 394, would be cut through a rocky ridge about 400 feet left (east) of the dam.

d. The reservoir, up to elevation 394, created by this dam would extend about 10 miles up Maiden Creek. It would make it necessary to move a railroad line, numerous roads, the communities of Lenhartsville, Virginville and part of Moselem. The cost estimates include amounts for these relocations. There are no commercially developed mineral resources in the reservoir area, but Onyx Cave which has been developed as a tourist attraction would be inundated. The value of this cave has been included in the estimated cost of lands and damages.

TABLE U-6

MAIDEN CREEK PROJECT COST ESTIMATE

Description	Estimated Cost
Lands and Damages	$ 6,548,000
Relocations	8,637,000
Reservoir Clearing	551,000
Dam and Appurtenant Works	6,420,000
Fish and Wildlife Facilities 1/	-
Recreation 2/	5,689,000
Building, Grounds, Utilities	31,000
Engineering and Design	1,408,000
Supervision and Administration	1,564,000
TOTAL PROJECT COST	$30,848,000

1/ Appendix J contains means of mitigating losses to stream fisheries, game habitat, and public hunting expected to be caused by the project. These means include habitat improvement and public hunting opportunity on 4,400 acres of land needed in Berks County, Pennsylvania. The cost required to provide these mitigations is a project cost, and while omitted from the estimate above is taken into account in the economic analyses in Appendix V.

2/ This cost includes engineering, design, supervision, and administration

TABLE U-6

MAIDEN CREEK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and severance	acre	$ 209	2,850	$ 597,000
Improvements	unit	10,736	425	4,563,000
Resettlement	unit	500	387	195,000
Easement	acre	129	620	80,000
Contingencies, 15%				815,000
Acquisition				298,000
Total, Lands and Damages				6,548,000
Relocations				
Highways				
Improve U.S. Route No.22 and bridge	job	l.s.	-	628,000
Relocate primary hard surface road	mile	$ 170,000	4.6	782,000
Relocate secondary hard surface road	mile	110,000	6.2	682,000
New bridges (13) for secondary hard surface roads	job	l.s.	-	1,807,000
Improved graded road	mile	57,000	2.8	160,000
Contingencies, approx.25%				1,015,000
Subtotal, Highways				5,074,000
Railroad				
Relocate railroad	mile	$148,500	9.8	1,456,000
New bridge for railroad	job	l.s.	8	1,010,000
Contingencies, approx.25%				616,000
Subtotal, Railroad				3,082,000
Utilities and Cemeteries				
Relocate petroleum line	mile	$ 56,000	4.3	$ 241,000
Relocate elect. line	mile	5,000	10.8	54,000
Cemetery	grave	200	450	90,000
Contingencies, approx.25%				96,000
Subtotal, Utilities and Cemeteries				481,000
Total, Relocations				8,637,000
Engineering and Design				777,000
Supervision and Administration				864,000

TABLE U-6

MAIDEN CREEK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing				
Agricultural land	acre	$ 80	1,700	$ 136,000
Building sites	acre	50	80	4,000
Stream bed	acre	-	50	0
Woodland, light clearing	acre	80	280	22,400
Woodland, medium clearing	acre	210	500	105,000
Woodland, heavy clearing	acre	350	290	101,500
Farm units	each	500	70	35,000
Dwelling units, year round	each	100	262	26,200
Dwelling units, summer	each	50	55	2,800
Commercial and industrial units	each	200	32	6,400
Churches, schools, etc.	each	200	6	1,200
Contingencies, approx. 25%				110,500
Total, Reservoir Clearing				551,000
Engineering and Design				50,000
Supervision and Administration				55,000
Dam and Appurtenant Works				
Embankment				
Clearing and grubbing	acre	600	36	22,000
Diversion and care of stream	job	l.s.	-	72,000
Stripping for dam	c.y.	0.90	97,000	87,000
Excavation, cutoff trench	c.y.	1.00	12,000	12,000
Excavation, pervious borrow	c.y.	0.60	660,000	396,000
Excavation, impervious borrow	c.y.	0.65	607,000	395,000
Excavation, random borrow	c.y.	0.65	220,000	143,000
Foundation preparation	s.y.	7.00	6,000	42,000
Pervious fill, compacted	c.y.	0.30	768,000	230,000
Impervious fill, compacted	c.y.	0.30	551,000	165,000
Rock fill, compacted	c.y.	0.35	300,000	105,000
Random fill, compacted	c.y.	0.25	328,000	82,000
Filter material, processed	c.y.	3.90	97,000	378,000
Additional compaction	hour	15.00	600	9,000
Drilling and pressure grouting	l.f.	10.00	7,000	70,000
Service road	mile	70,000	0.5	35,000
Guard rail	l.f	3.00	5,300	16,000
Riprap, dumped	c.y.	12.00	44,000	528,000
Contingencies, approx. 20%				557,000
Subtotal, Embankment				3,344,000

TABLE U-6

MAIDEN CREEK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works - Cont'd				
Outlet Works				
Excavation, common	c.y.	$ 1.00	3,000	$ 3,000
Excavation, rock	c.y.	2.00	13,000	26,000
Close line drilling	s.f.	4.00	6,000	24,000
Foundation preparation	s.y.	7.00	1,000	7,000
Drilling and pressure grouting	l.f.	10.00	600	6,000
Drilling and grouting anchors	l.f.	8.00	500	4,000
Backfill	c.y.	2.00	5,000	10,000
Concrete, intake chan. and tower substruct.	c.y.	60.00	1,700	102,000
Concrete, intake tower	c.y.	110.00	800	88,000
Concrete, conduit	c.y.	60.00	3,600	216,000
Concrete, stilling basin	c.y.	50.00	600	30,000
Cement	bbl.	6.00	10,000	60,000
Reinforcing steel	lb.	0.20	340,000	68,000
Miscellaneous metal	lb.	0.60	50,000	30,000
Rubber water stops	l.f.	3.00	2,000	6,000
Service bridge	s.f.	40.00	3,400	136,000
Operating house superstructure	job	l.s.		25,000
Spiral stairway	job	l.s.		5,000
Sluice gates	lb.	0.60	170,000	102,000
Gate operating system	job	l.s.		12,000
Bypass system	job	l.s.		15,000
Float well and drain system	job	l.s.		13,000
Lighting and power system	job	l.s.		11,000
Heating and ventilating system	job	l.s.		6,000
Trolley hoist	job	l.s.		9,000
Chain hoist	job	l.s.		1,000
Tile gauge	job	l.s.		3,000
Contingencies, approx. 20%				204,000
Subtotal, Outlet Works				1,222,000
Spillway				
Excavation, common	c.y.	0.65	70,000	45,000
Excavation, rock	c.y.	1.80	418,000	752,000
Excavation, structural, rock	c.y.	5.00	1,000	5,000
Close line drilling	s.f.	4.00	10,300	41,000
Drilling and pressure grouting	l.f.	9.00	1,500	13,000
Concrete, spillway piers	c.y.	60.00	1,100	66,000

TABLE U-6

MAIDEN CREEK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works - Continued				
Spillway - Continued				
Concrete, spillway weir	c.y.	$ 30.00	900	$ 27,000
Bridge deck, etc.	s.f.	25.00	22,400	560,000
Cement	bbl.	6.00	2,800	17,000
Reinforcing steel	lb.	0.18	104,000	19,000
Contingencies, approx.20%				309,000
Subtotal, Spillway				1,854,000
Total, Dam and Appurtenant Works				6,420,000
Engineering and Design				578,000
Supervision and Administration				642,000
Recreation				
Facilities 1/	job	l.s.	-	2,987,000
Real Estate, 5,600 acres	job	l.s.	-	2,702,000
Total, Recreation				5,689,000
Building, Grounds, Utilities				
Administration, maintenance building, etc.	job	l.s.		25,000
Contingencies, approx. 25%				6,000
Total, Building, Grounds, Utilities				31,000
Engineering and Design				3,000
Supervision and Administration				3,000

1/ Includes contingencies, engineering, design, supervision and administration.

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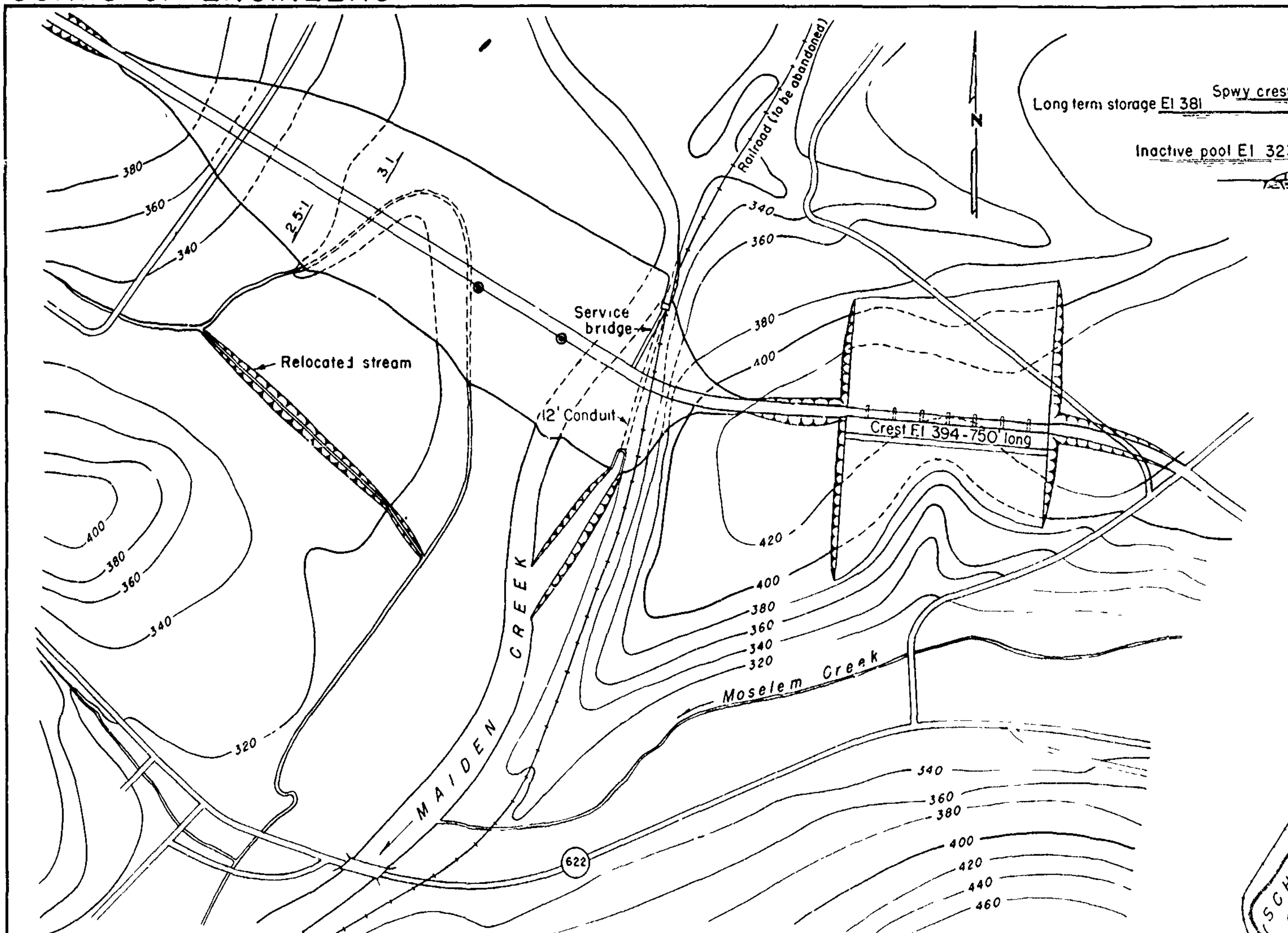
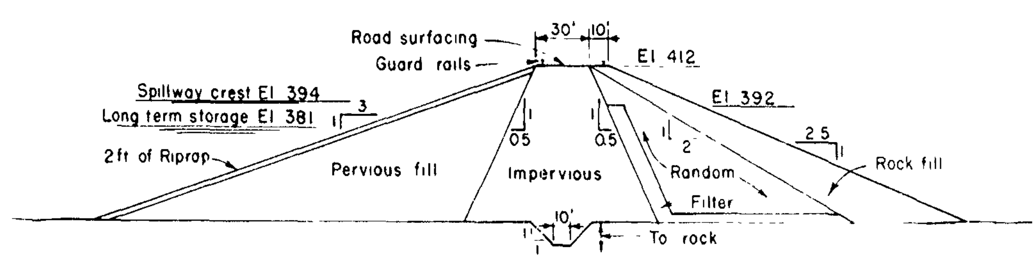


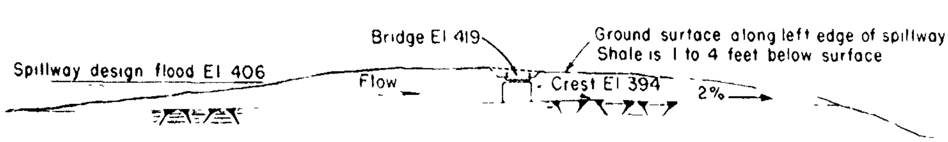
PLAN

300 0 300 600 FEET



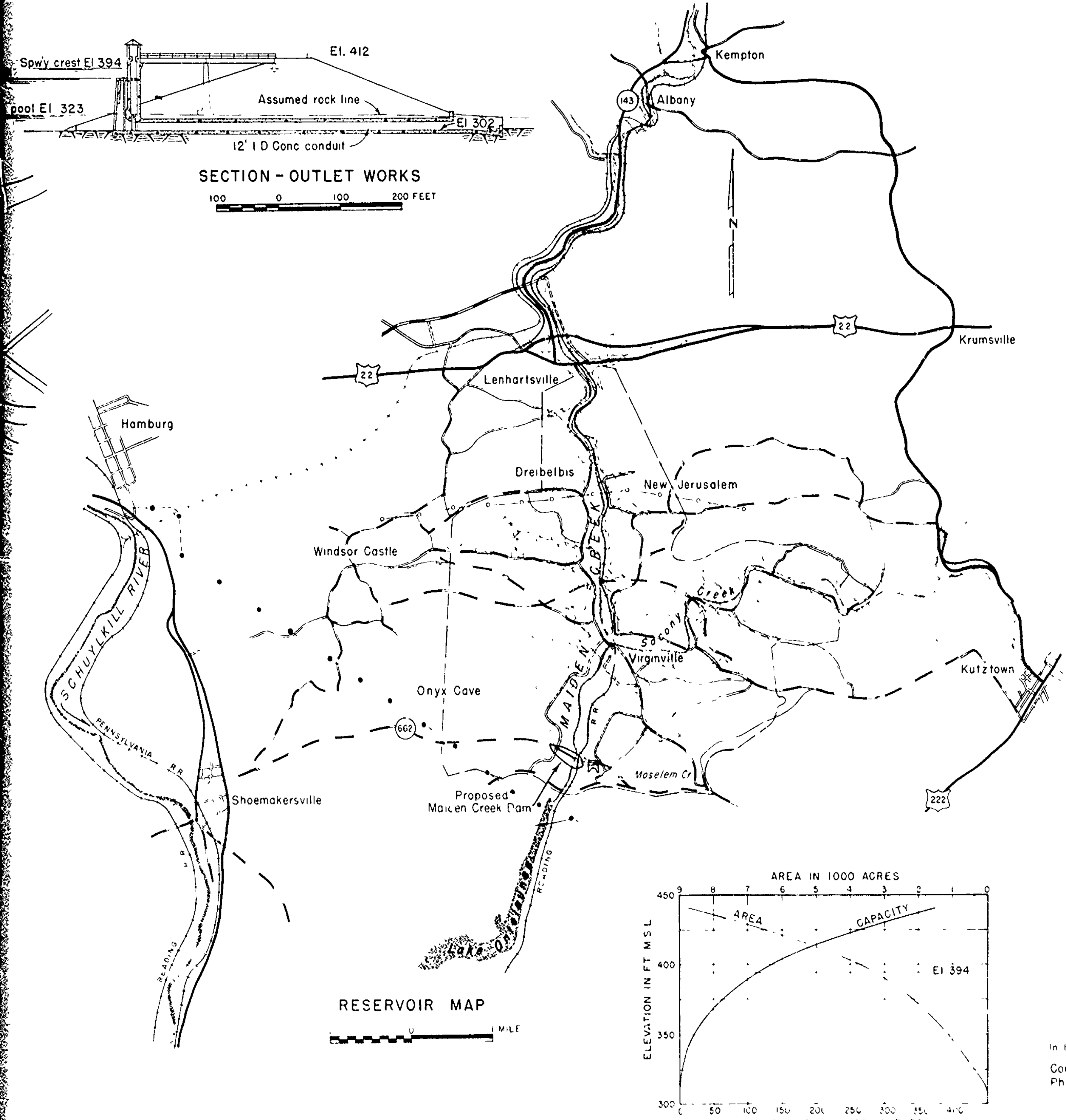
TYPICAL SECTION-DAM

50 0 50 100 FEET



LONGITUDINAL SECTION - SPILLWAY

100 0 100 200 FEET



SECTION - OUTLET WORKS

RESERVOIR MAP

RESERVOIR AREA AND CAPACITY CURVES

Pottsville

READI

LEGE

REVIEW

MAI

In 1 Sheet

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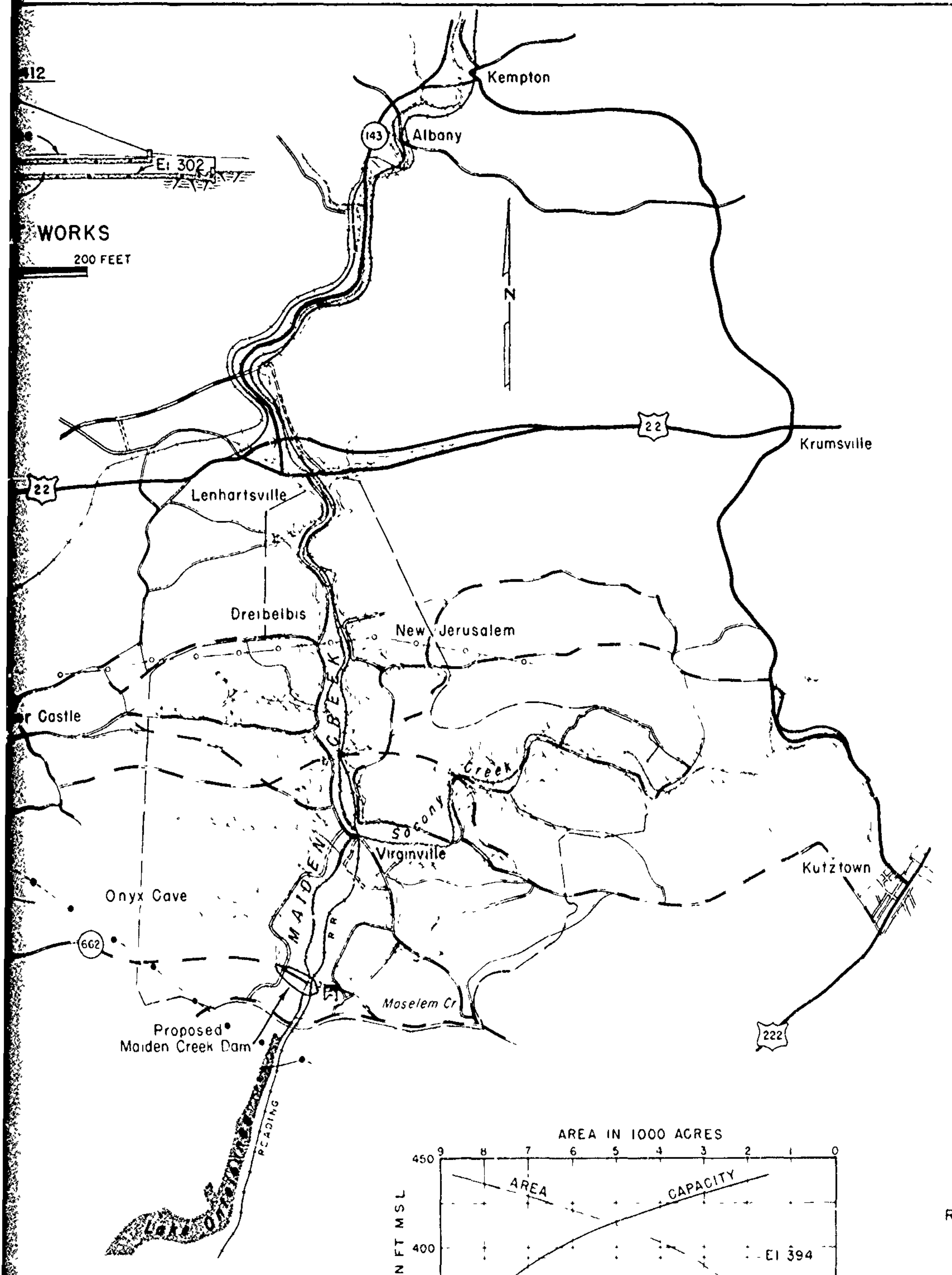
Philadelphia,

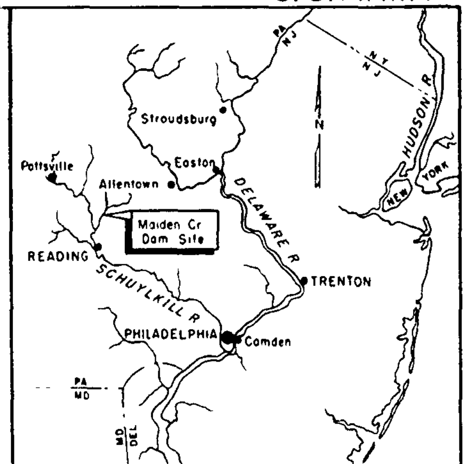
Drawer No 2

U.S. ARMY



RESERVOIR MAP

0 1 MILE

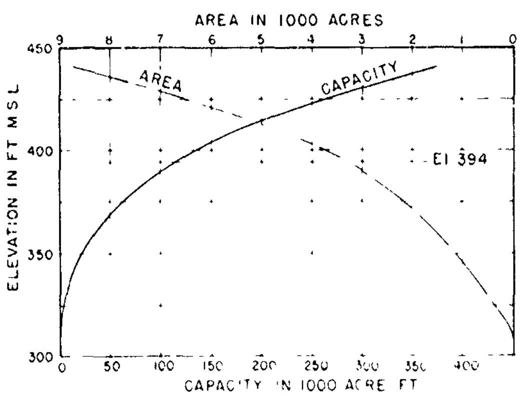


LOCATION MAP

SCALE

LEGEND

- Reservoir at El 394
- Long Term Storage El 381
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Existing Petroleum Line
- Proposed Relocated Graded Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Railroad
- Proposed Relocated Petroleum Line
- Land Acquisition for Recreation Development
- Drill Hole



RESERVOIR AREA AND CAPACITY CURVES

REVIEW REPORT DELAWARE RIVER BASIN

MAIDEN CREEK PROJECT

In 1 Sheet — Scale as Shown

Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

Drawer No 228 — File No 29094

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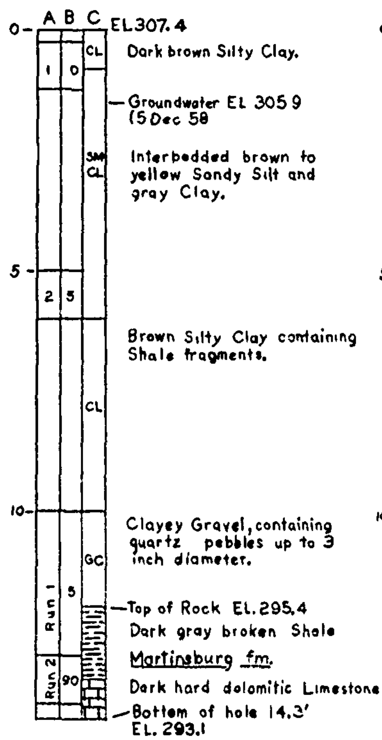
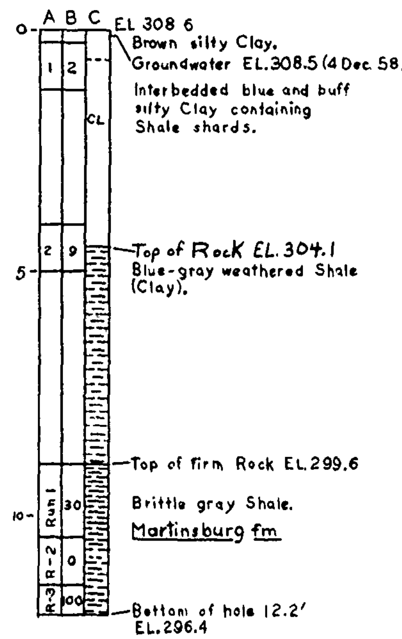
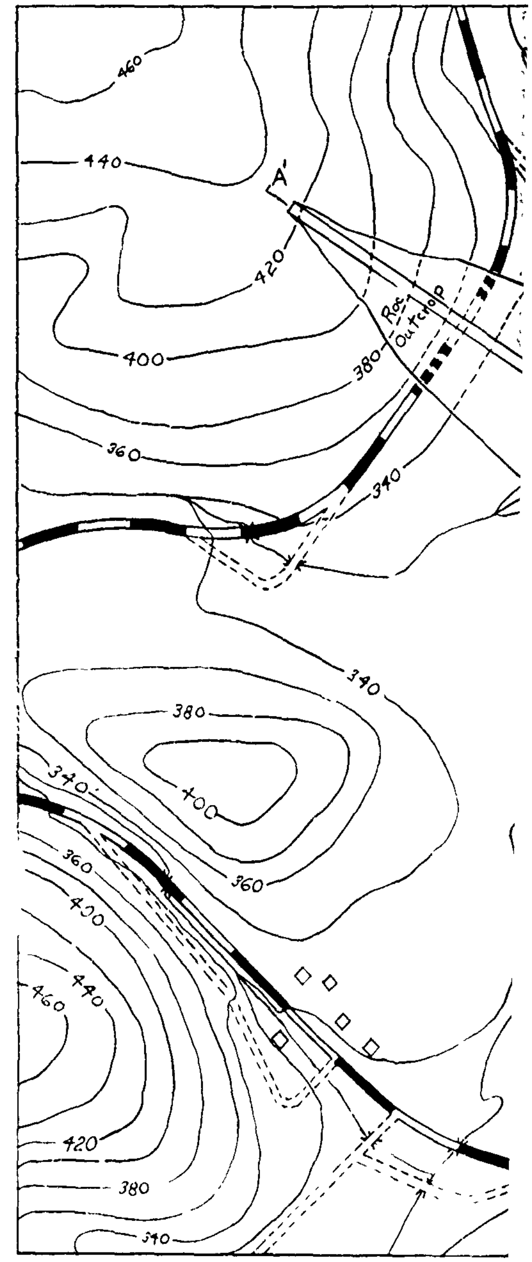


B.H. #1

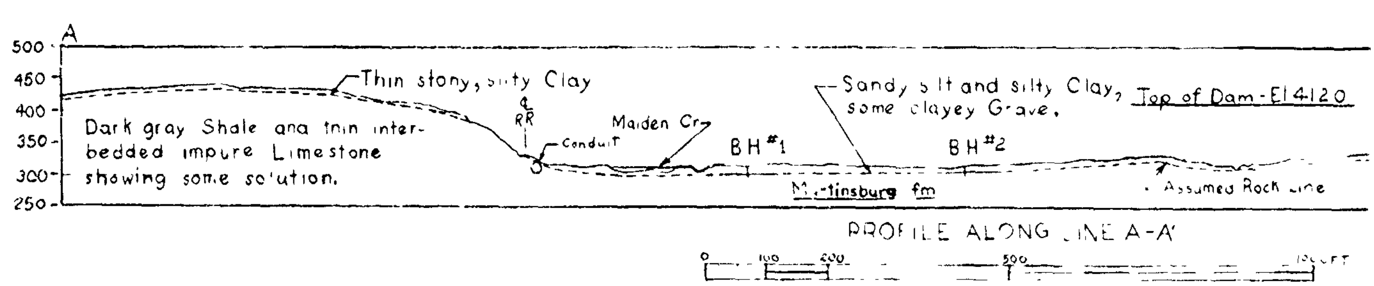


B.H. #2



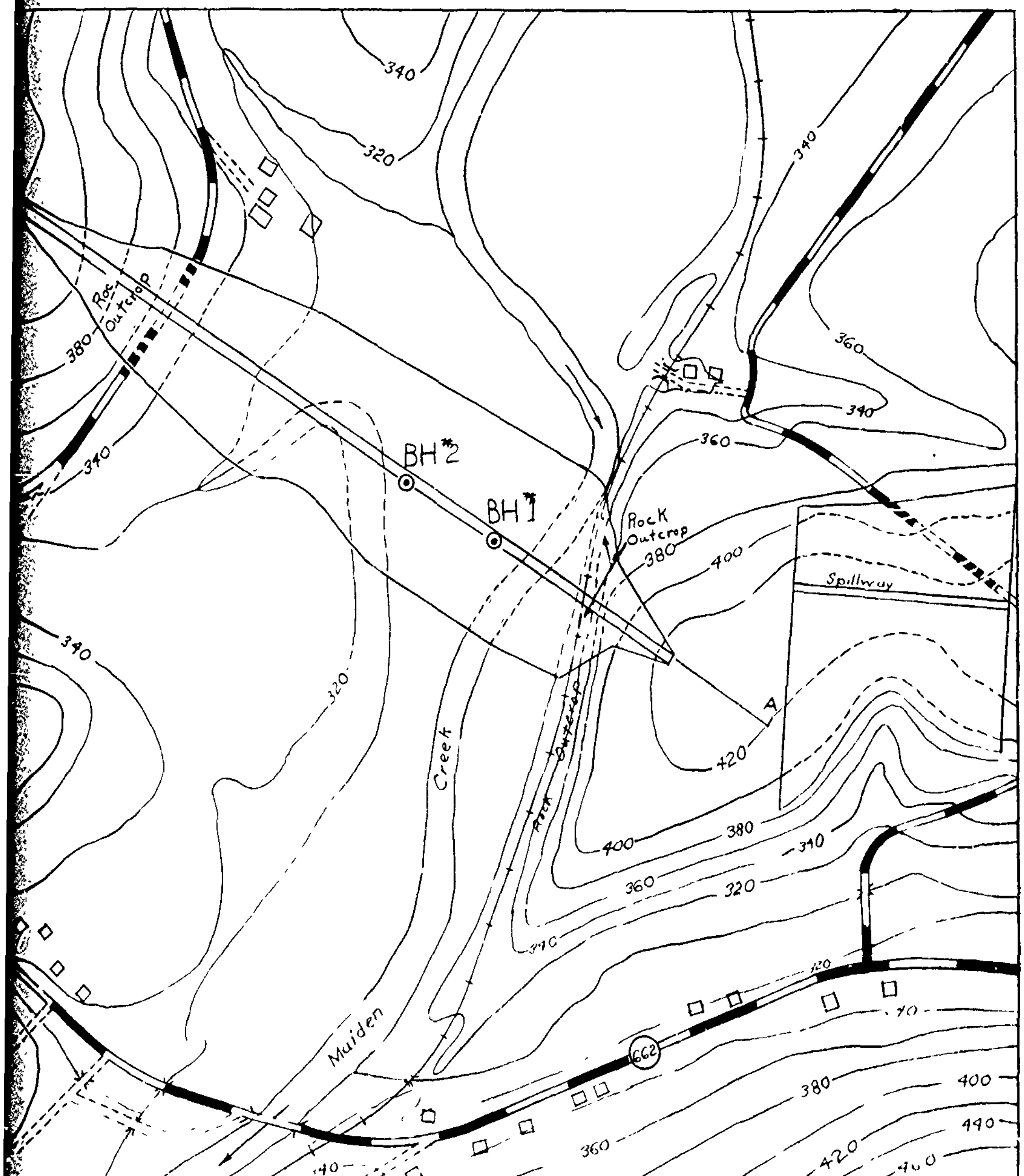
NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of spoon and core samples
2. Column "A" refers to the sample or core run number.
3. Column "B" refers to the number of blows a 140 lb hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered, or percent core recovery for interval shown.
4. Column "C" is a field classification of the materials encountered, using the Unified Soil Classification System symbols and graphic rock symbols
5. All elevations based on mean sea level datum.
6. Drilling performed by U.S. Corps of Engineers, Phila Dist, Nov 1958.



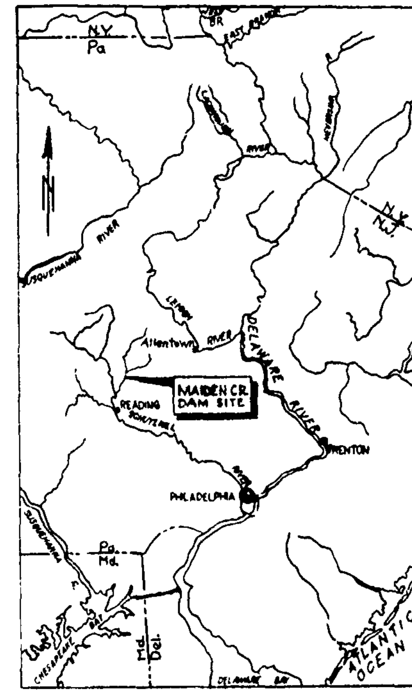
PROFILE ALONG LINE A-A'

U. S. ARMY

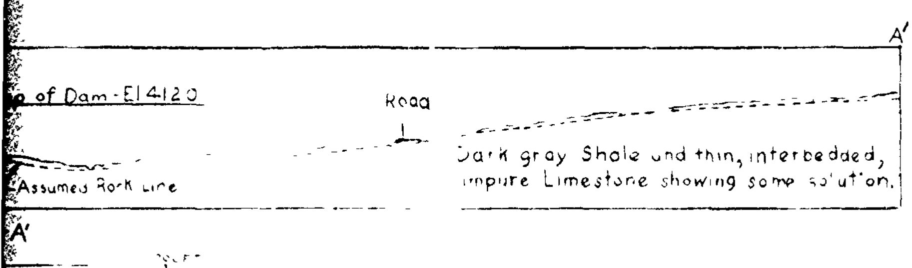


SITE MAP

0 100 200 600 1000 FEET



LOCATION MAP



REVIEW REPORT DELAWARE RIVER BASIN

MAIDEN CREEK PROJECT
GEOLOGIC DATA

In Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
12 Jan 60

Drawer No 228

File No 29088

PLATE 13

28. Prompton Project

a. Prompton dam, now under construction and scheduled for completion in 1960, lays across the valley of the Lackawaxen River about 1/2 mile upstream from the confluence of Waymart Branch with the River, and about 4 miles northwest of Honesdale, Pennsylvania. The dam, which controls 60 square miles of drainage area, will be 1,300 feet long and 140 feet high. The spillway which is cut into the rock hill around the right (west) end of the dam is 50 feet wide at the base with side slopes of 1/2:1. The present dam and reservoir are being built to retard floods. A conduit 8'9" in diameter has been built along the right riverbank to carry limited amounts of flow. This conduit has an uncontrolled inlet at elevation 1,125 in the reservoir pool and a stilling basin at the downstream end.

b. Data pertaining to subsurface formations and material are shown on eight drawings in "Plans for Construction of Prompton Dam and Appurtenant Structures" issued by the Philadelphia District.

c. It is proposed that the structures be modified to make it possible to hold long term storage up to elevation 1,180 and to control release of water from the reservoir. This proposal will make it necessary to make the following additions or modifications to the structures:

1. Construct a control tower with gates and a service bridge to control releases from the reservoir.

2. Add a blanket of impervious material on the valley walls and floor upstream from the dam. This material will be obtained from a previously developed borrow area along route 170 about 1/2 mile upstream from the dam.

3. Widen the spillway to 250 feet.

4. Clear reservoir land and move roads subject to inundation.

d. Data on basic dimensions of the project after completion of the modifications are as follows:

Capacities

Long term, 31,400 ac.-ft., stream bed to elevation 1,180
Short term, 20,300 ac.-ft., between elevation 1,180 and elevation 1,205

Elevations

Top of dam, 1,226
Spillway crest, 1,205
Outlet, upstream invert, 1,112
Stream bed at dam, 1,085

Areas

Reservoir at elevation 1,180, 720 acres
Reservoir at elevation 1,205, 910 acres

e. The valley at the dam site was formed originally by preglacial stream erosion cutting through relatively horizontal strata of sandstone and shale. Postglacial deposits cover the bed-rock with accumulations more than 150 feet in depth occurring in the valley floor, and relatively thin lateral moraine and drift cover on the valley walls. The glacial materials are generally considered impervious, however, some interconnected, relatively permeable lenses occur throughout the valley cross section.

f. The outlet works of the present structure is founded on unconsolidated overburden. In the proposed modification the control tower would be founded on this material. The cost estimate provides for the tower to be placed on a spread footing foundation with the required excavation surrounded by well points for un-watering and stabilization during construction. The dense glacial till upon which this structure would stand is amply firm to support it.

g. The reservoir which would be created by this dam, as modified, would, when filled with flood water up to elevation 1,205, extend about five miles upstream, and would inundate nearly the same area that has been placed under flood-easement agreements for the reservoir created by the present dam. However, the reservoir which would be created by the modified Prompton Dam would require that 380 acres of land now under flood-easement agreements be procured as part of the area to be inundated by the long-term storage pool; and that 30 acres additiona land (land in addition to that under flood easement because of the present dam) be placed under a flood-easement agreement. There are no communities nor commercially developed mineral deposits in the reservoir area.

TABLE U-7
PROMPTON PROJECT COST ESTIMATE

Description	Estimated Cost
Lands and Damages	$ 62,000
Relocations	414,000
Reservoir Clearing	43,000
Dam & Appurtenant Works, Modifications	2,700,000
Fish & Wildlife Mitigations 1/	-
Access Road	54,000
Recreation 2/	814,000
Buildings, Grounds & Utilities	31,000
Engineering & Design	292,000
Supervision & Administration	323,000
TOTAL PROJECT COST	$4,733,000

1/ Information regarding the acquisition of land and streams relative to the recovery of fish and wild-life losses comparable to that given for the Aquashicola project has not been received.
2/ This cost includes engineering, design, supervision, and administration.

TABLE U-7
PROMPTON PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and Severance (now under easement), 380 ac	job	l.s.		$ 34,000
Improvements	-	-	0	0
Resettlement	-	-	0	0
Easement and Severance	acre	$60.00	30	2,000
Contingencies 15%				5,000
Acquisition				21,000
Total, Lands and Damages				62,000
Relocations				
Highways				
Relocation, primary hard surface road	mile	$100,000	2.25	225,000
Improvement, secondary hard surface road	mile	50,000	1.50	75,000
New culvert for primary hard surface road	job	l.s.	1	20,000
Contingencies, Approx 25%				80,000
Subtotal, Highways				400,000
Utilities				
Relocate service pole line	mile	5,000	2.25	11,000
Contingencies, Approx. 25%				3,000
Subtotal, Utilities				14,000
Total - Relocations				414,000
Engineering and Design				37,000
Supervision and Administration				41,000

TABLE U-7
PROMPTON PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing				
Agricultural Land	acre	$ 80.00	350	$ 28,000
Woodland, medium clearing	acre	210.00	30	6,000
Contingencies, Approx. 25%				9,000
Total, Reservoir Clearing				43,000
Engineering and Design				4,000
Supervision and Administration				4,000
Dam and Appurtenant Works				
Outlet Works				
Diversion and Protective Works	job	l.s.	-	80,000
Excavation, intake structure	c.y.	0.60	12,000	7,000
Backfill, intake structure	c. y.	1.50	11,000	17,000
Excavation, intake channel	c.y.	1.00	2,000	2,000
Riprap, intake channel	c.y.	3.00	700	2,000
Concrete, tower substructure	c.y.	60.00	730	44,000
Concrete , tower superstructure	c.y.	110.00	1,000	110,000
Concrete, plug	c.y.	60.00	80	5,000
Concrete, conduit extension	c.y.	60.00	500	30,000
Cement	bbl.	6.00	3,000	18,000
Reinforcing Steel	lb.	0.20	180,000	36,000
Miscellaneous Metal	lb.	0.60	41,000	25,000
Spiral Stairway	job	l.s.	-	5,000
Sluice Gates	lb.	0.60	180,000	108,000

TABLE U-7
PROMPTON PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works - Continued				
Outlet Works - Continued				
Gate Operating System	job	l.s.	-	$ 2,000
By pass System	job	l.s.	-	8,000
Floatwell & Drain System	job	l.s.	-	15,000
Lighting & Power System	job	l.s.	-	11,000
Heating & Ventilating System	job	l.s.	-	6,000
Trolley Hoist, 5-ton	job	l.s.	-	9,000
Chain Hoist, 1-1/2-ton	job	l.s.	-	1,000
Tile Gage	job	l.s.	-	3,000
Service Bridge	s.f.	$40.00	3,700	148,000
Contingencies, Approx. 20%				138,000
Subtotal, Outlet Works				830,000
Blanket				
Fill, compacted impervious	c.y.	0.80	137,000	110,000
Backfill, uncompacted	c.y.	0.60	14,000	8,000
Contingencies, Approx. 20%				24,000
Subtotal, Blanket				142,000

TABLE U-7
PROMPTON PROJECT COST ESTIMATE

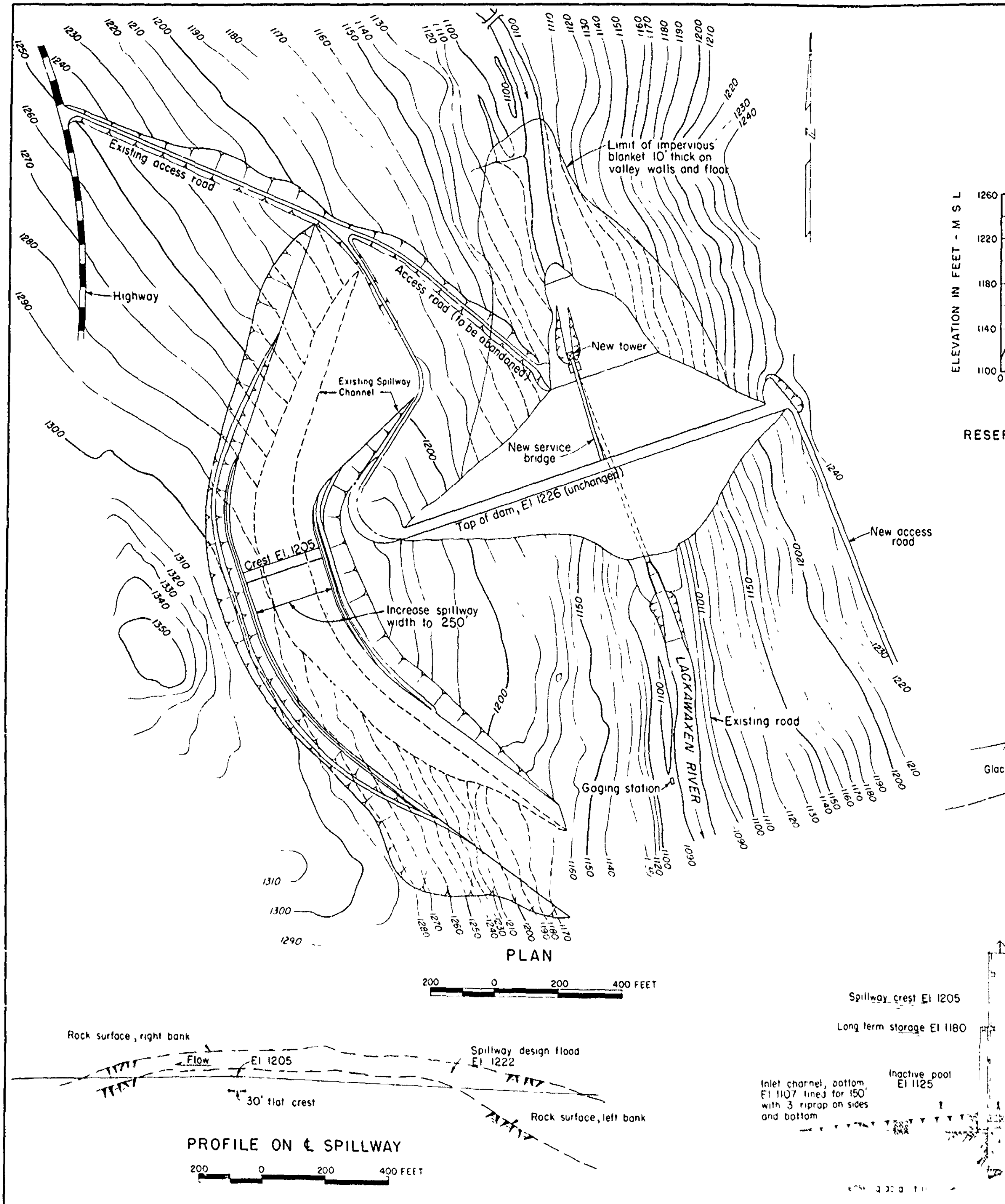
Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works - Continued				
Spillway Englarging				
Excavation, common	c.y.	$ 0.60	230,000	$ 138,000
Excavation, rock	c.y.	2.10	620,000	1,302,000
Contingencies, 20%				288,000
Subtotal, Spillway Englarging				1,728,000
Total, Dam and Appurtenant Works (outlet, blanket, and spillway)				2,700,000
Engineering and Design				243,000
Supervision and Administration				270,000
Access Road				
New Road	mile	60,000.00	0.75	45,000
Contingencies 20%				9,000
Total, Access Road				54,000
Engineering and Design				5,000
Supervision and Administration				5,000
Recreation				
Facilities 1/	job	l.s.	-	607,000
Real Estate, 1325 ac.	job	l.s.	-	207,000
Total, Recreation				814,000

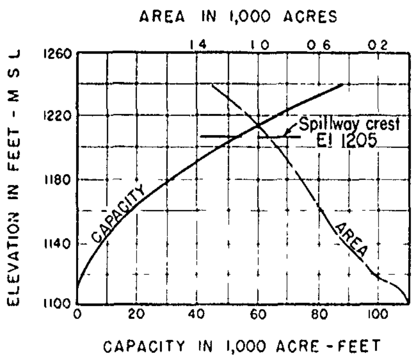
1/ Includes contingencies, engineering, design, supervision and administration

TABLE U-7
PROMPTON PROJECT COST ESTIMATE

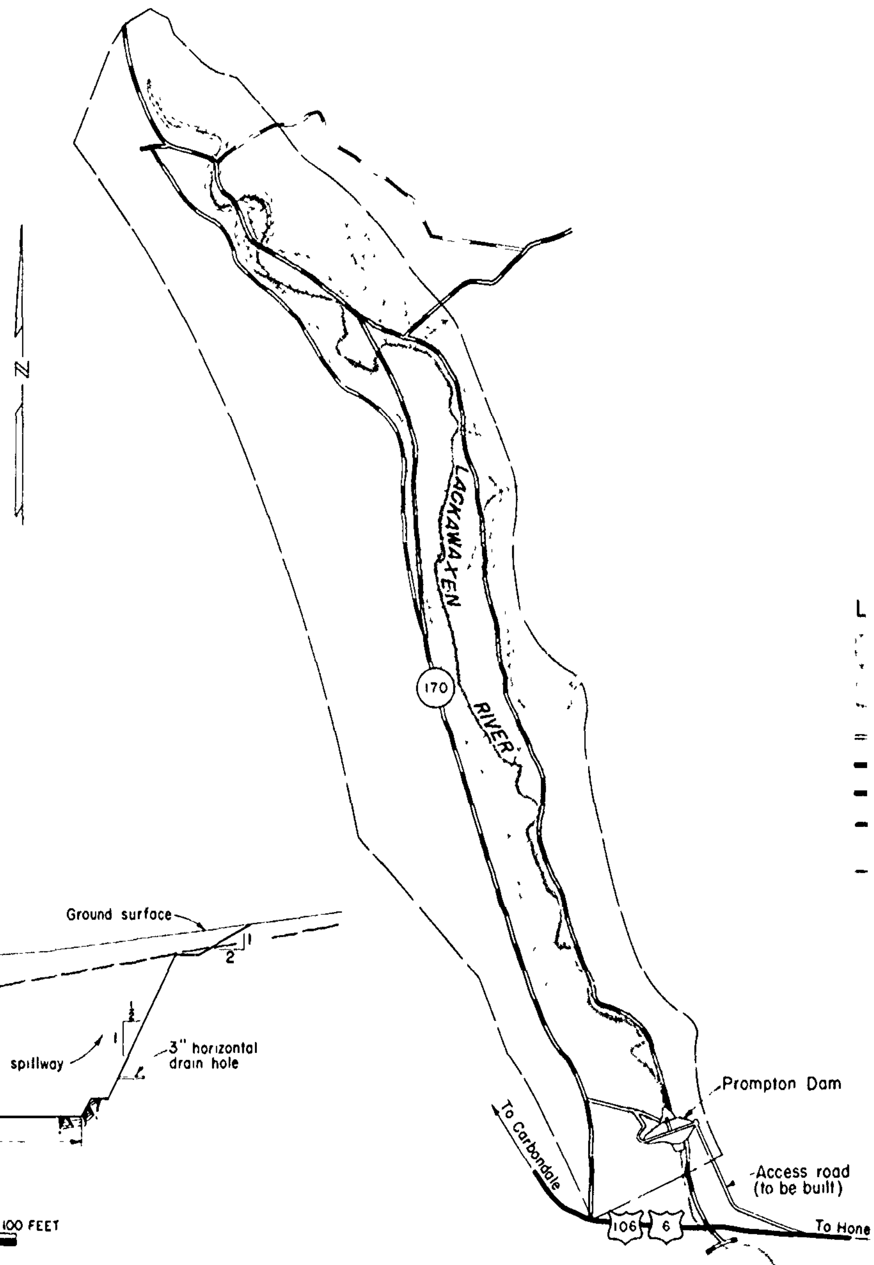
Description	Unit	Unit Price	Quantity	Cost
Buildings, Grounds, Utilities				
Administration, Maintenance Buildings, etc.	job	l.s.	1	$25,000
Contingencies, Approx. 25%				6,000
Total, Buildings, Grounds, Utilities				31,000
Engineering and Design				3,000
Supervision and Administration				3,000

CORPS OF ENGINEERS

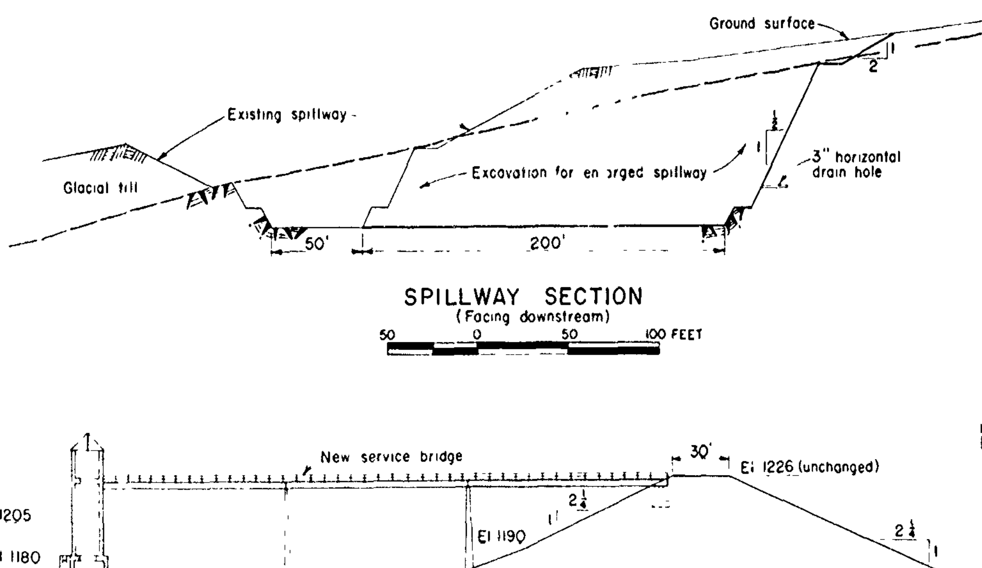




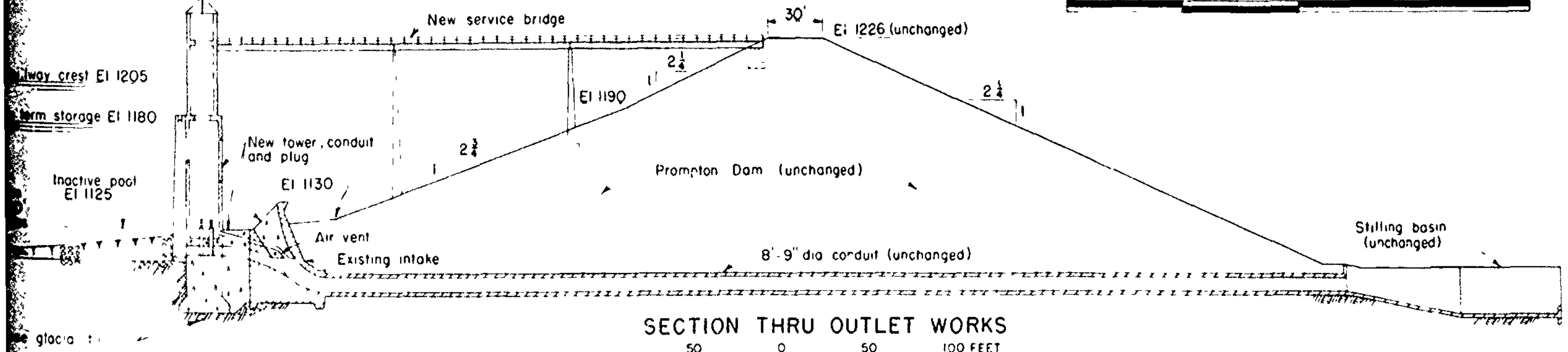
RESERVOIR AREA AND CAPACITY CURVES



RESERVOIR MAP

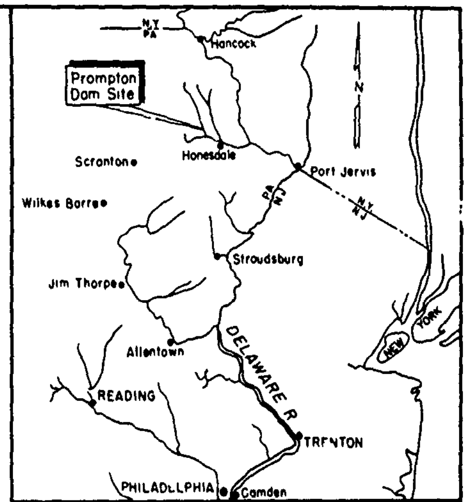


SPILLWAY SECTION
(Facing downstream)



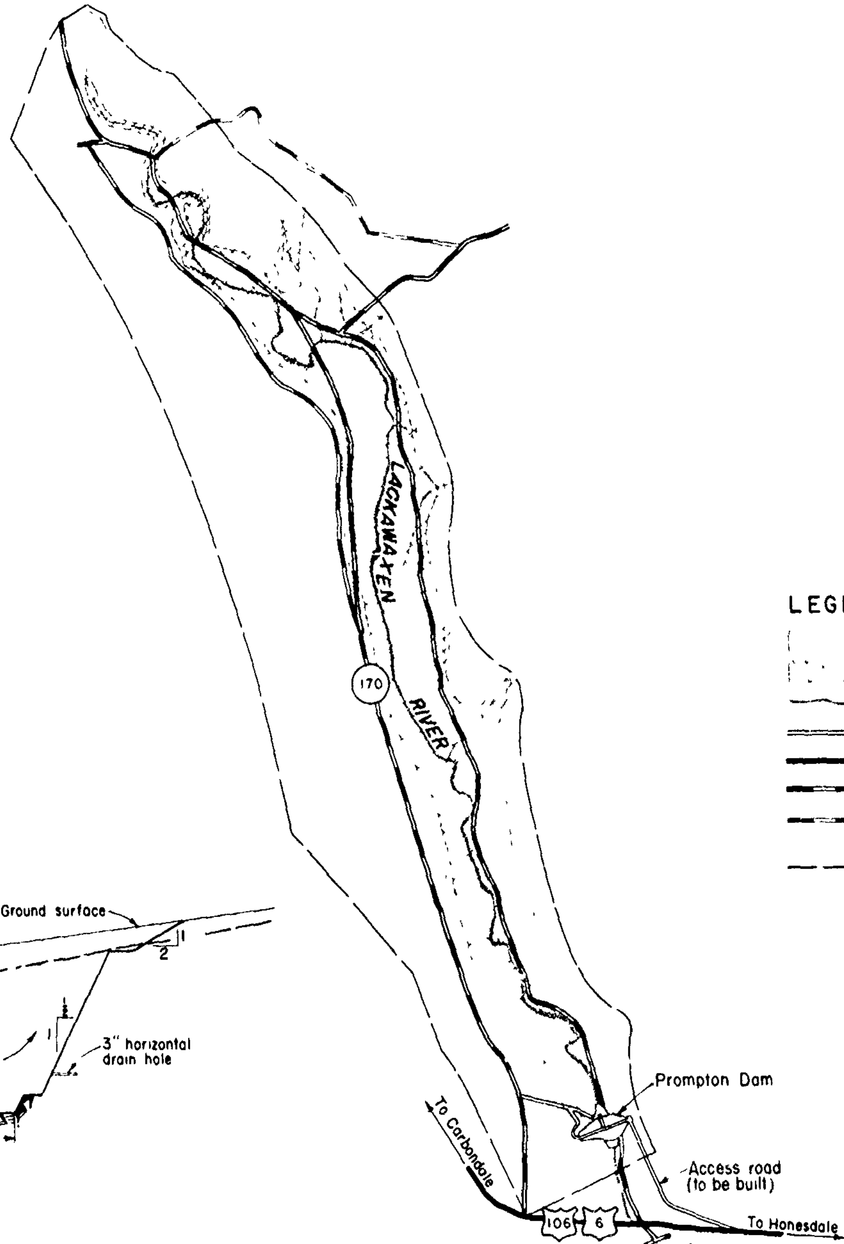
SECTION THRU OUTLET WORKS

U. S. ARMY



LOCATION MAP

SCALE

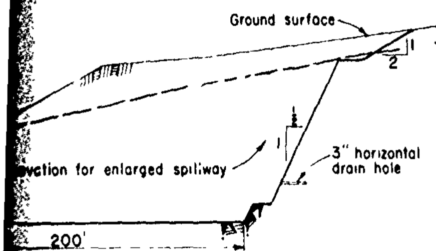


LEGEND

- Reservoir at El 1205
- Long Term Storage El 1180
- Existing Stream
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Proposed Relocated Secondary Hard Surface Road
- Land Acqisition for Recreation Development

RESERVOIR MAP

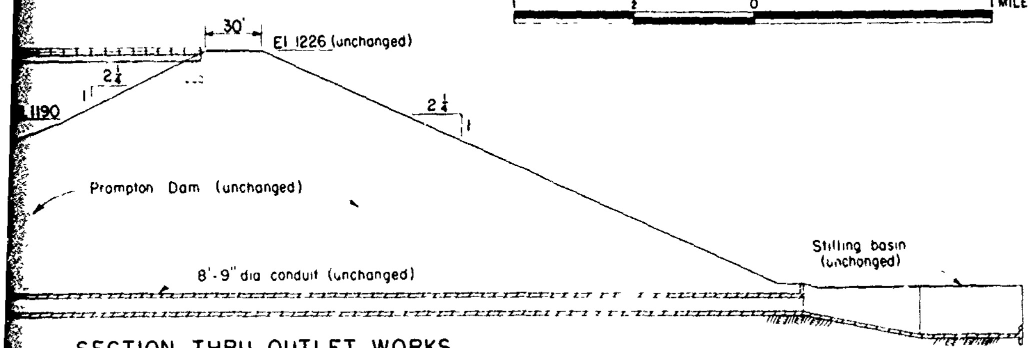
1 ½ 0 1 MILE



...Y SECTION

(... downstream)

50 100 FEET



SECTION THRU OUTLET WORKS

50 0 50 100 FEET

REVIEW REPORT DELAWARE RIVER BASIN

PROMPTON PROJECT, MODIFIED

In 1 Sheet

Scale as Shown

Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

Drawer No 228

File No 29101

29. <u>Tocks Island Project</u>

a. Tocks Island Dam, as proposed, would be located across the Delaware River valley about 5 miles upstream from the Delaware Water Gap and about 7 miles northeast of Stroudsburg, Pennsylvania. The site is at the upstream end of Tocks Island which is about 2-1/2 miles upstream from Shawnee-On-Delaware, Pennsylvania. The drainage area above this location is 3,827 square miles. Data on basic dimensions of the project are as follows:

<u>Capacities</u>
Long term, 490,000 ac.-ft., stream bed to elevation 410
Short term, 275,000 ac.-ft., between elevation 410 and elevation 428

<u>Elevations</u>
Top of dam, 456
Bottom of spillway gates, 395
Top of spillway gates, 428
Outlet, upstream invert, 305
Stream bed at dam, 296

<u>Areas</u>
Reservoir at elevation 410, 12,100 acres
Reservoir at elevation 428, 15,640 acres

<u>Power</u>
Installed capacity, conventional, 46,000 kilowatts
Installed capacity, pumped storage, 366,000 kilowatts

b. At the proposed dam site, the Delaware River is incised into Paleozoic rocks, forming a valley 1,800 feet wide rising steeply on the left (south) bank to an ultimate elevation of over 1,500 feet. On the right bank a terrace about 800 feet wide, at elevation 400, extends from the riverbank to the bottom of a steep slope which rises to elevation 860, then rises on a more gradual slope to an elevation of over 1,000 feet. Overburden in the valley consists of a great mass of unconsolidated sediments of Pleistocene glacial origin, 190 feet thick in the riverbed and covered by a thin veneer of Recent alluvium on the flood plain. While part of the glacial deposits are moderately to highly permeable, the tight alluvium and clayey (weathered) upper glacial deposits will act as an effective blanket over the permeable portions of the overburden. The left abutment is composed of partially metamorphosed red shales and sandstones which contain green shale interbeds. In the valley floor and on the right abutment these shales and sandstones are overlain by limestone, calcareous shale and some sandstone to the top of the hill, where shale is exposed. Considerable solution exists in the calcareous shale and the limestone. Subsurface conditions were investigated for a distance of 4.3 miles up and down the valley from the dam site by seismic methods; and in closer

proximity to the dam site 15 holes were drilled and 3 test samples of possible embankment material were obtained. Results of these investigations are shown on plates 17, 18, 19 and 20.

c. The dam, 3,200 feet long, would consist of about 3-1/2 million cubic yards of earth and rock, rising 160 feet above the riverbed to elevation 456. It would have a central impervious earth core which would extend to a maximum depth of 30 feet below the dam. The embankment would consist of impervious material from borrow areas upstream from the dam near the existing road on the right side, and rock from the spillway excavation. Two 22-foot diameter conduits placed on rock along the left riverbank would serve both as outlet conduits and penstocks. Flow in these conduits would be controlled by slide gates at the upper end. The part downstream from the middle of the dam would be lined with steel.

d. At the downstream end of the conduits there would be a conventional powerplant with two turbine-driven generators of 23,000-kilowatt capacity each. All water released would pass through the turbines or through a bypass channel from each penstock built into the powerhouse substructure. A pressure release valve on each penstock would protect against high surge pressures. Electric current from the powerplant would be transformed to 110 kilovolts in the switchyard.

e. A pumped-storage powerplant, installed underground, would be located upstream of the embankment. The capacity of the plant would be 366,000 kilowatts. This plant would draw water for pumping to storage from Tocks Island Reservoir through conduits and discharge through penstocks and a tunnel to an upper reservoir on top of the ridge about 1,130 feet higher than Tocks Island Reservoir. For generating power water would flow from the upper reservoir through the same penstocks, conduits and units back into the Tocks Island Reservoir. The powerhouse would be reached by means of a shaft. A service bridge would connect the top of shaft with the required intake structure. The switchyard for the pumped-storage powerplant would be on ground adjacent to the top of shaft. An access road to the top of shaft and the switchyard would be provided from the proposed relocated road.

f. The spillway cut into the left (New Jersey) abutment would have a concrete crest at elevation 395, about 100 feet above the riverbed, and would be surmounted by 10 radial gates each 40 feet long by 33 feet high. The spillway chute, which would be cut into partially metamorphosed red shales and sandstones, attains depths ranging up to 220 feet. Because of these depths, a special study of the rock formations along the spillway would be made, when more detailed design studies are undertaken, in order to determine the most economical safe slopes or combination of slopes and berms to be used for such deep cuts. For cost estimating purposes a side slope of 4 vertical to 1 horizontal, with no berms, was assumed. The concrete lined spillway chute would discharge flood waters into a stilling basin downstream from the conventional powerplant and from there into the river channel.

g. Diversion would be accomplished by conveying water through the 22-foot diameter concrete conduits with upstream diversion dams or cofferdams that, after closure, would be incorporated into the main dam.

h. The reservoir formed by this dam, up to elevation 428, top of the gates, would extend approximately nine miles up Flat Brook, from its mouth, and 37 miles (measured along the stream) up the Delaware River to Port Jervis, New York. It would necessitate the relocation of 27 miles of U. S. Highway 209, as well as county roads, local roads, the community of Bushkill, Pennsylvania, parts of Dingmans Ferry, Pennsylvania, and a few buildings at Milford, Pennsylvania. The highway bridge across the river south of Milford is high enough to be above the reservoir. Matamoras would be protected by a dike about 12,000 feet long, with outlet pipes, drains, intercepting pipelines and pumping plants. In the vicinity of Port Jervis, the bridge to Matamoras is above the reservoir level, but the bridge on U. S. route 6 to Tristate, New York, would have to be replaced. No railroad relocations would be required. There are no commercially valuable mineral deposits in the reservoir site.

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Total Estimated Cost
Lands and Damages	$ 16,713,000
Relocations	11,223,000
Reservoir Clearing and Dikes	3,268,000
Dam and Appurtenant Works	20,867,000
Fish and Wildlife, Mitigation of Losses 1/	2,100,000
Power Plant, Conventional	10,365,000
Power Plant, Pumped Storage	45,259,000
Access Road	12,000
Recreation 2/	49,825,000
Building, Grounds, Utilities	60,000
Engineering and Design	8,379,000
Supervision and Administration	9,310,000
TOTAL PROJECT COST	$177,381,000

1/ Includes only fish handling facilities at the dam. Appendix J enumerates means of mitigating losses to stream fisheries, game habitat, and public hunting opportunity expected to be caused by the project. These means include the acquisition of public fishing rights and development of public use facilities along 27 miles of streams and in habitat improvement and public hunting opportunity on 12,300 acres of land in New Jersey and Pennsylvania. The cost required to provide these mitigations is a project cost, and while omitted from the estimate above is taken into account in the economic analyses in Appendix V.

2/ Includes engineering, design, supervision, and administration.

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Land and Damages				
Land and severance, 14,800 ac.	job	l.s.		$ 3,041,000
Improvements and resettlement	job	l.s.		10,[illegible],000
Easement, 1,428 ac.	job	l.s.		36[illegible],000
R.O.W. for dikes around Matamoras	job	l.s.		114,000
Contingencies, approx. 15%				2,091,000
Acquisition	ownership	$700	970	679,000
Total, Land and Damages				16,713,000
Relocations				
Highways				
Improve existing U.S.209, 3 lane	mile	150,000	3.0	450,000
Improve existing secondary road to become U.S. 209, 2 lane	mile	100,000	15.0	1,500,000
Relocate U. S. 209, 2 lane	mile	150,000	9.0	1,350,000
New bridges (3) for U. S. 209	job	l.s.		1,626,000
New bridge for U. S. 6	job	l.s.		140,000
Improve existing secondary hard surface road	mile	49,000	10.1	495,000
Relocate secondary hard surface road	mile	105,000	18.8	1,974,000
New bridges (3) for secondary hand surface road	job	l.s.		773,000
Relocate graded road	mile	50,000	1.0	50,000
Contingencies, approx. 25%				2,090,000
Subtotal, Highways				10,448,000
Utilities and Cemeteries				
Reinforce transmission line	job	l.s.		40,000
Relocate service pole line	mile	5,000	36	180,000
Relocate cemeteries (3)	grave	200	2,000	400,000
Contingencies, approx. 25%				155,000
Subtotal, Utilities and Cemeteries				775,000
Total, Relocations				11,223,000
Engineering and Design				1,010,000
Supervision & Administration				1,122,000

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing and Dikes				
Reservoir clearing				
Agricultural land	acre	$ 80	3,750	$ 300,000
Building lots	acre	50	1,300	65,000
River bed	acre	0	2,400	0
Woodland, light clearing	acre	80	1,500	120,000
Woodland, medium clearing	acre	210	3,750	787,500
Woodland, heavy clearing	acre	350	2,100	735,000
Farm Units	each	500	30	15,000
Residences and Cottages	each	50	710	35,500
Camps, summer	each	1,000	5	5,000
Commercial buildings	each	400	55	22,000
Special Purpose buildings	each	400	25	10,000
Contingencies, approx. 25%				524,000
Subtotal, Reservoir clearing				2,619,000
Dikes around Matamoras				
Embankment, 121,500 c.y. with surfacing, riprap and grass	job	l.s.		270,000
Excavation for ditches	c.y.	0.60	11,700	7,000
Interceptor pipe line, 8200 ft.	job	l.s.	-	145,000
Pumping plants and drains	job	l.s.		97,000
Contingencies, approx. 25%				130,000
Subtotal, Dikes around Matamoras				649,000
Total, Reservoir Clearing and Dikes				3,268,000
Engineering and Design				294,000
Supervision & Administration				327,000
Dam and Appurtenant Works				
Embankment				
Clearing and grubbing	acre	600	34	20,000
Diversion and care of river	job	l.s.	-	180,000
Stripping	c.y.	1.00	110,000	110,000
Excavation, cutoff trench	c.y.	0.90	88,000	79,000
Excavation, impervious borrow	c.y.	0.54	605,000	327,000

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works cont'd				
Embankment, cont'd				
Impervious fill, compacted	c.y.	$ 0.33	552,000	$ 182,000
Rock fill, compacted	c.y.	0.30	2,421,000	726,000
Random material	c.y.	0.30	389,000	117,000
Additional compaction	hour	15.00	1,400	21,000
Filter material	c.y.	3.80	143,000	543,000
Bedding material	c.y.	1.60	74,000	118,000
Derrick stone	c.y.	5.00	16,000	80,000
Drilling and pressure grouting	l.f.	8.00	12,000	96,000
Relief wells	l.f.	20.00	100	2,000
Service road	mile	50,000	0.5	25,000
Contingencies, approx. 20%				525,000
Subtotal, Embankment				3,151,000
Outlet Works				
Clearing and grubbing	acre	600	2	1,000
Stripping	c.y.	1.00	3,000	3,000
Excavation, common	c.y.	0.80	23,000	18,000
Excavation, rock	c.y.	1.80	53,500	96,000
Foundation preparation	c.y.	5.00	5,400	27,000
Close line drilling	s.f.	4.00	34,000	136,000
Drilling and pressure grouting	l.f.	8.00	1,500	12,000
Drilling and grouting anchors	l.f.	10.00	4,000	40,000
Concrete, intake structure	c.y.	70.00	8,000	560,000
Concrete, conduit	c.y.	40.00	29,000	1,160,000
Concrete, walls, etc.	c.y.	60.00	1,000	60,000
Cement	bbl.	6.00	47,500	285,000
Reinforcing steel	lb.	0.16	1,600,000	256,000
Miscellaneous metal	lb.	0.60	320,000	192,000
Gates (5)	lb.	0.60	375,000	225,000
Gate hoist, 80 T. Cap.	job	l.s.	-	80,000
Rubber water stops	l.f.	2.50	2,000	5,000
Service bridge	s.f.	40.00	4,200	168,000
Operating house superstructure	job	l.s.	-	120,000
Spiral stairway	job	l.s.	-	10,000
Gate operating system	job	l.s.	-	15,000
Float well and drain system	job	l.s.	-	15,000
Lighting and power system	job	l.s.	-	50,000
Heating and ventilating system	job	l.s.	-	30,000

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works cont'd				
Outlet Works, cont'd				
Standby electric generator	job	l.s.	-	$ 8,000
Bridge Crane, 50 ton	job	l.s.	-	50,000
Stream gauge	job	l.s.	-	30,000
Contingencies, approx. 20%				730,000
Subtotal, Outlet Works				4,382,000
Spillway				
Clearing and grubbing	acre	600	30	18,000
Excavation, common	c.y.	0.80	223,000	178,000
Excavation, rock	c.y.	1.70	3,305,000	5,619,000
Close line drilling	s.f	4.00	70,000	280,000
Drilling and grouting anchors	l.f.	-		200,000
Drilling drain holes	job	l.s	-	50,000
Drilling and pressure grouting	l.f.	8.00	5,700	46,000
Concrete, wall lining	c.y.	40.00	3,200	128,000
Concrete, channel paving	c.y.	25.00	36,000	900,000
Concrete, retaining walls	c.y.	30.00	20,000	600,000
Concrete, spillway piers	c.y.	50.00	7,400	370,000
Concrete, spillway wier	c.y.	30.00	11,000	330,000
Concrete, baffles and end fill	c.y.	40.00	800	32,000
Bridge deck	s.f.	10.00	7,500	75,000
Cement	bbl.	6.00	97,000	582,000
Reinforcing steel	lb.	0.16	1,600,000	256,000
Rubber water stops	l.f.	2.50	4,000	10,000
Drains, channel paving	job	l.s.		172,000
Foundation preparation	s.y.	5.00	40,000	200,000
Handrail, bridge & retaining wall	l.f.	4.00	1,600	6,000
Taintor gates	lb.	0.40	1,900,000	760,000
Gate hoists	each	30,000	10	300,000
Contingencies, approx. 20%				2,222,000
Subtotal, Spillway				13,334,000
Total, Dam and Appurtenant Works				20,867,000
Engineering & Design				1,878,000
Supervision and Administration				2,087,000

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Fish and Wildlife Facilities				
Fish handling facilities	job	l.s.		$ 1,750,000
Contingencies, 20%				350,000
Total, Fish and Wildlife Facilities				2,100,000
Engineering and Design				189,000
Supervision and Administration				210,000
Power Plant, Conventional				
Penstocks				
Steel lining	lb.	$ 0.32	1,480,000	474,000
Mastic coating	s.y.	2.00	6,400	13,000
Pressure relief valves (2)	lb.	0.60	45,000	27,000
Contingencies, approx. 20%				103,000
Subtotal, Penstocks				617,000
Substructure				
Cofferdams & unwatering	job	l.s.	-	340,000
Excavation, common	c.y.	0.80	2,600	2,000
Excavation, rock	c.y.	1.80	16,300	29,000
Close line drilling	s.f.	4.00	4,500	18,000
Foundation preparation	s.y.	5.00	1,600	8,000
Drilling & pressure grouting	l.f.	8.00	800	6,000
Concrete, mass	c.y.	25.00	15,100	378,000
Concrete, floor finish	s.f.	0.40	12,200	5,000
Cement	bbl.	6.00	21,000	126,000
Reinforcing steel	lb.	0.16	302,000	48,000
Miscellaneous metal	lb.	0.60	22,000	13,000
Rubber water stops	l.f.	2.50	400	1,000
Handrail	l.f.	4.00	150	1,000
Steel, machine support	lb.	0.50	43,200	22,000
By-pass gates (2), 4' x 6'	lb.	0.60	44,000	26,000
Contingencies, 20%				204,000
Subtotal, Substructure				1,227,000

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Power Plant, Conventional cont'd				
Superstructure				
Concrete, walls	c.y.	$ 70.00	1,800	$ 126,000
Cement	bbl	6.00	2,300	14,000
Reinforcing steel	lb.	0.16	144,000	23,000
Steel, structural	lb.	0.40	297,000	119,000
Miscellaneous metal	lb.	0.60	1,800	1,000
Roof, complete	s f.	2.10	11,500	24,000
Door, overhead	job	l.s.	-	9,000
Windows	s.f	4.25	8,700	37,000
Contingencies, approx. 20%				71,000
Subtotal, Superstructure				424,000
Tailrace				
Clearing and grubbing	acre	600.00	2	1,000
Stripping	c.y.	1.00	4,000	4,000
Excavation, common	c.y	0.80	2,600	2,000
Excavation, rock	c.y.	1.80	16,300	29,000
Riprap	c.y	4 50	1,700	8,000
Derrick stone	c.y.	5.00	2,600	13,000
Contingencies, approx. 20%				11,000
Subtotal, Tailrace				68,000
Equipment				
Turbines, 2 at 33,000 hp ea.	job	l.s.	-	2,847,000
Generators, 2 at 23,000 kw ea.	job	l.s.	-	2,530,000
Appurtenant equipment	job	l.s.	-	117,000
Accessory electric equipment	job	l.s.	-	586,000
Crane, 225 T cap.	job	l.s.	-	225,000
Contingencies, approx. 20%				1,261,000
Subtotal, Equipment				7,566,000
Service Road				
New road to dam	mile	50,000	0.4	20,000
Along face of dam	mile	40,000	0.2	8,000
Contingencies, approx. 20%				6 000
Subtotal, Service Road				34,000

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Power Plant, Conventional cont'd				
Switchyard 1/				
Foundations, structures, grading, fencing & grounding	job	l.s.		$ 105,000
Cable, conduit & switches	job	l.s.		86,000
Transformers, 25,000 KVA cap.	each	$ 105,000	2	210,000
Bus wiring, etc.	job	l.s.		21,000
Miscellaneous construction	job	l.s.		7,000
Subtotal, Switchyard				429,000

1/ This estimate was made by Federal Power Commission. Estimated amounts for the individual items include contingencies.

Total, Conventional -Power Facilities (Penstocks, Power Plant, Tailrace; Equipment, Service Road, and Switchyard)				10,365,000
Engineering and Design				933,000
Supervision & Administration				1,036,000
Power Plant, Pumped Storage				
Upper Reservoir				
Land including severance	acre	220	175	38,500
Acquisition		l.s.		2,000
Contingencies, approx. 15%				5,500
Subtotal, Land				46,000
Reservoir clearing	acre	210	175	36,800
Contingencies, approx. 25%				9,200
Subtotal, Reservoir Clearing				$ 46,000
Dikes around upper reservoir	job	l.s.		6,120,000
Contingencies, 20%				1,224,000
Subtotal, Dikes				7,344,000

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Power Plant, Pumped Storage - cont'd				
Upper Reservoir, cont'd				
Tunnel intake				$ 710,000
Contingencies, 20%				142,000
Subtotal, Tunnel Intake				852,000
Access Road to Upper Reservoir 4.2 miles	job	l.s.	-	650,000
Contingencies, 20%				130,000
Subtotal, Access Road to Upper Reservoir				780,000
Tunnel, Penstocks and Valves				
Tunnel, four penstocks and four butterfly valves				9,750,000
Contingencies, 20%				1,950,000
Subtotal, Tunnel, Penstocks and Valves				11,700,000
Intake structure and 4 conduits, Tocks Island Res. to pump-power plant				
Excavation, common	c.y.	0.80	11,000	9,000
Excavation, rock	c.y.	1.80	77,000	139,000
Close line drilling	s.f.	4.00	24,000	96,000
Concrete, inlet structure	c.y.	70.00	6,500	455,000
Concrete, conduits	c.y.	40.00	32,000	1,280,000
Concrete, collars	c.y.	70.00	300	21,000
Cement	bbl.	6.00	58,000	348,000
Reinforcing steel	lb.	0.18	2,500,000	450,000

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Power Plant, Pumped Storage, cont'd				
Intake structure and 4 conduits, cont'd.,				
Gates, 5	lb.	$ 0.60	800,000	$ 480,000
Hoist, 80 T cap.	job	l.s.	-	80,000
Miscellaneous metal	lb.	0.60	70,000	42,000
Rubber water stops	l.f.	2.50	1,200	3,000
Steel, conduit lining	lb.	0.32	1,078,000	345,000
Contingencies, approx. 20%				750,000
Subtotal, Intake Structure, etc.				4,498,000
Powerhouse and Pump-Power equipment				
Excavation, rock	c.y.	1.80	25,000	45,000
Close line drilling	s.f.	4.00	12,400	50,000
Substructure and superstructure	job	l.s.	-	1,195,000
Pump-Turbines and Governors (4) at125,000 hp ea.	job	l.s.	-	3,840,000
Generator - Motors and Exciters, four at 91,500 kw ea.	job	l.s.	-	6,595,000
Tests	job	l.s.	-	40,000
Accessory electric equipment	job	l.s.	-	1,000,000
Miscellaneous equipment	job	l.s.	-	580,000
Contingencies, 20%				2,669,000
Subtotal, Powerhouse and equipment				16,014,000

(Rev. Oct. 1960)

TABLE U-8

TOCKS ISLAND PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Power Plant, Pumped Storage, cont'd				
Switchyard for pump-power plant				
Excavation, rock	c.y.	$ 1.80	3,000	$ 5,000
Close line drilling	s.f.	4.00	3,200	13,000
Transformers and accessory equipment				3,298,000
Contingencies, approx. 20%				663,000
Subtotal, Switchyard				3,979,000
Total, Pumped-Storage Power Facilities (Upper Reservoir; tunnels, penstocks and valves; pump-power plant; 4 conduits from Tocks Island Res.; and switchyard)				45,259,000
Engineering and Design				4,069,000
Supervision and Administration				4,521,000

TABLE U-8

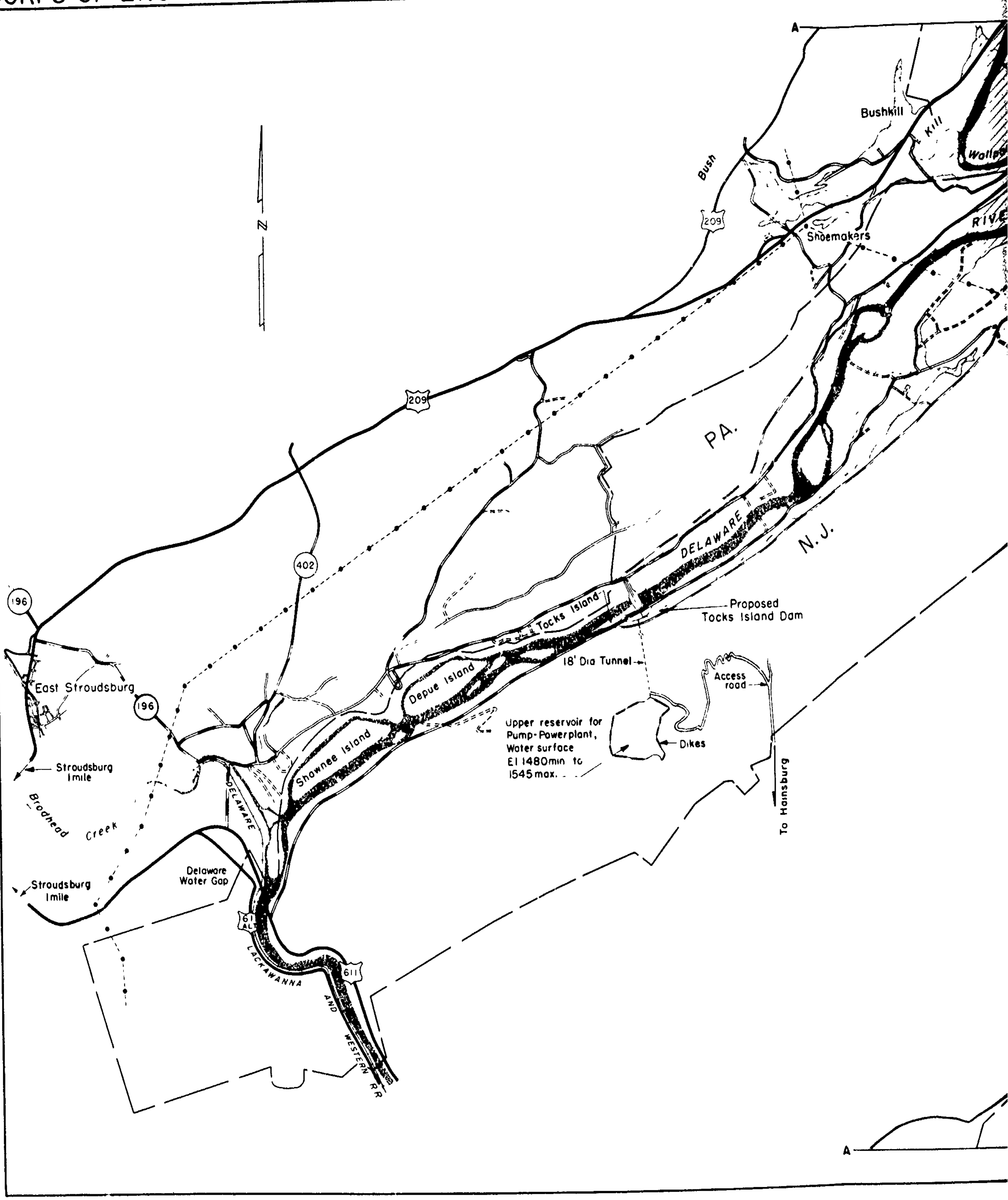
TOCKS ISLAND PROJECT COST ESTIMATE

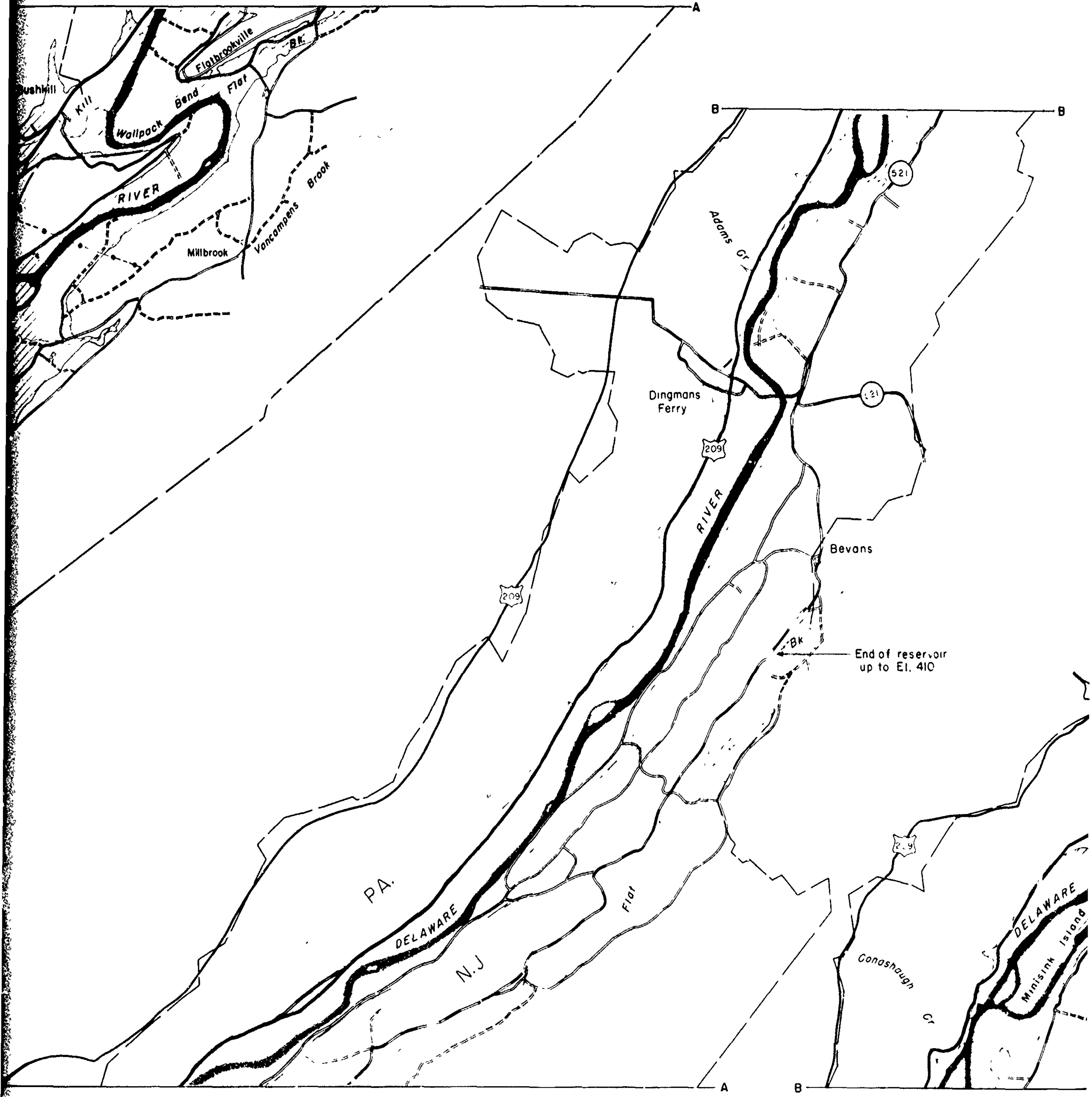
Description	Unit	Unit Price	Quantity	Cost
Access Road				
New road to dam	mile	$50,000	0.2	$ 10,000
Contingencies, 20%				2,000
Total, Access Road				12,000
Engineering and Design				1,000
Supervision and Administration				1,000
Recreation				
Facilities 1/	job	l.s.		28,382,000
Real Estate, 47,570 acres	job	l.s.		21,443,000
Total, Recreation				49,825,000

1/ Includes contingencies, engineering, design, supervision and administration.

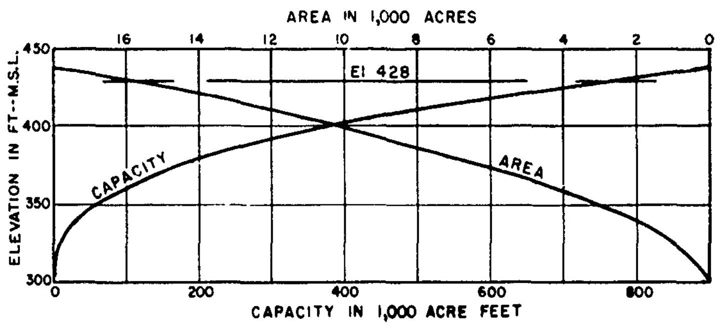
Description	Unit	Unit Price	Quantity	Cost
Building, Grounds, Utilities				
Administration, maintenance bldgs., etc.	job	l.s.		50,000
Contingencies, 20%				10,000
Total, Building, Grounds, Utilities				60,000
Engineering and Design				5,000
Supervision and Administration				6,000

CORPS OF ENGINEERS

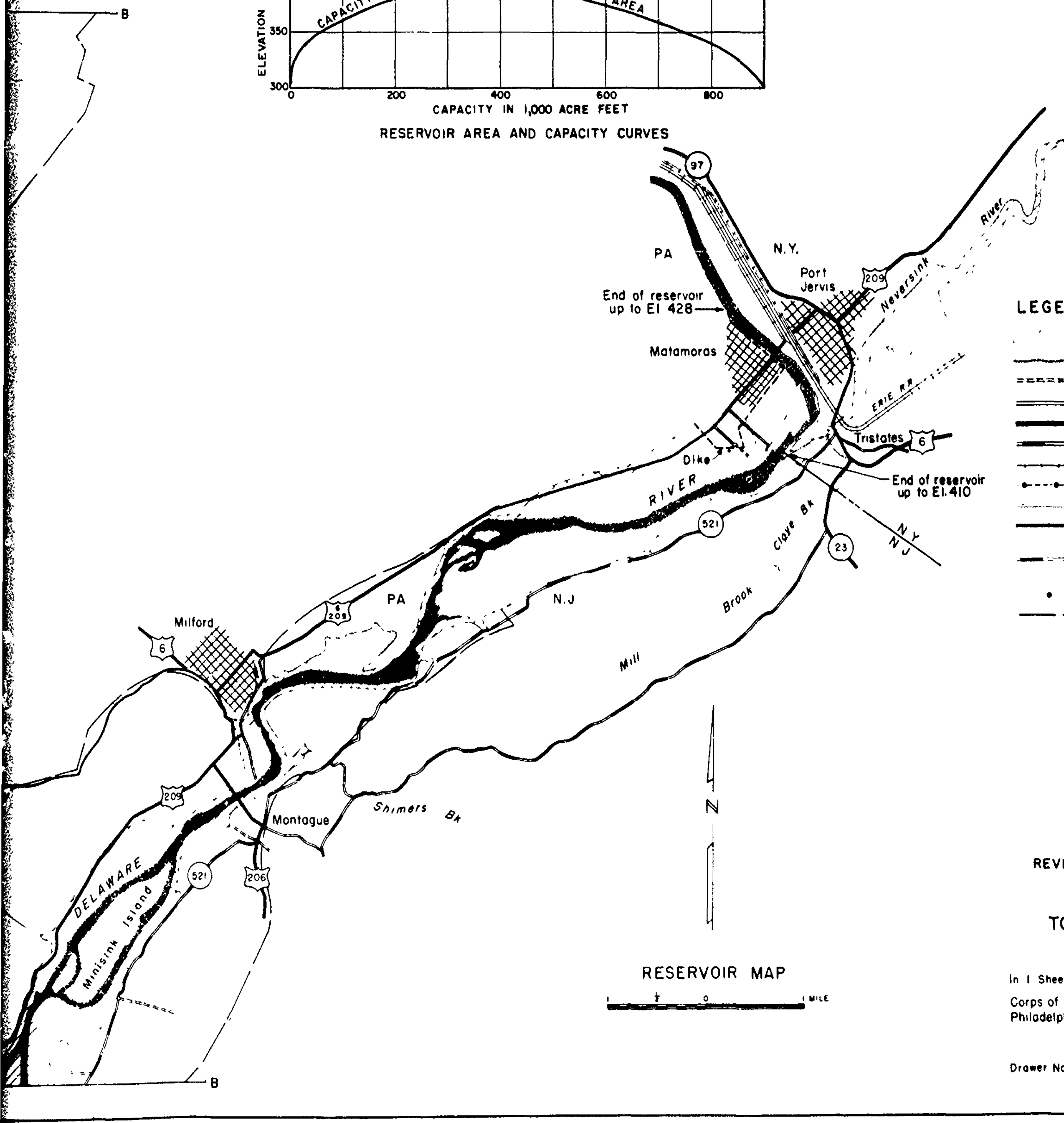




A
Bushkill
Kill
Wallpack
Bend
Flat
Flatbrookville
Bk.
RIVER
Vancampens
Brook
Millbrook
B
B
521
Adams Cr
Dingmans
Ferry
521
209
RIVER
Bevans
Bk
End of reservoir
up to El. 410
209
PA.
DELAWARE
N.J
Flat
209
Conashaugh
Cr
DELAWARE
Minisink Island
A
B



RESERVOIR AREA AND CAPACITY CURVES



RESERVOIR MAP

1 ½ 0 1 MILE

LEGEND

Multiple-Purp
Existing Stre
Dirt Road
Graded Road
Hard Surface,
Secondary Ha
Existing Railr
Existing Powe
Proposed Relo
Proposed Relo
Duty Road
Proposed Relo
Hard Surface
Proposed Rel
Land Acquisit
Development

REVIEW REPORT DELA

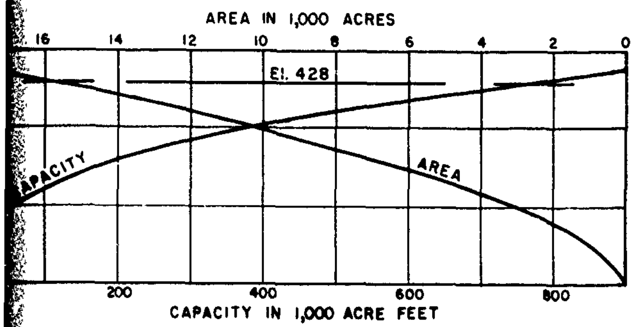
TOCKS ISLAND

In 1 Sheet

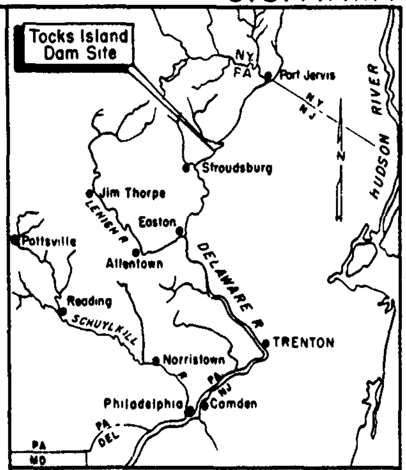
Corps of Engineers
Philadelphia, Pa

Drawer No 228

U.S. ARMY

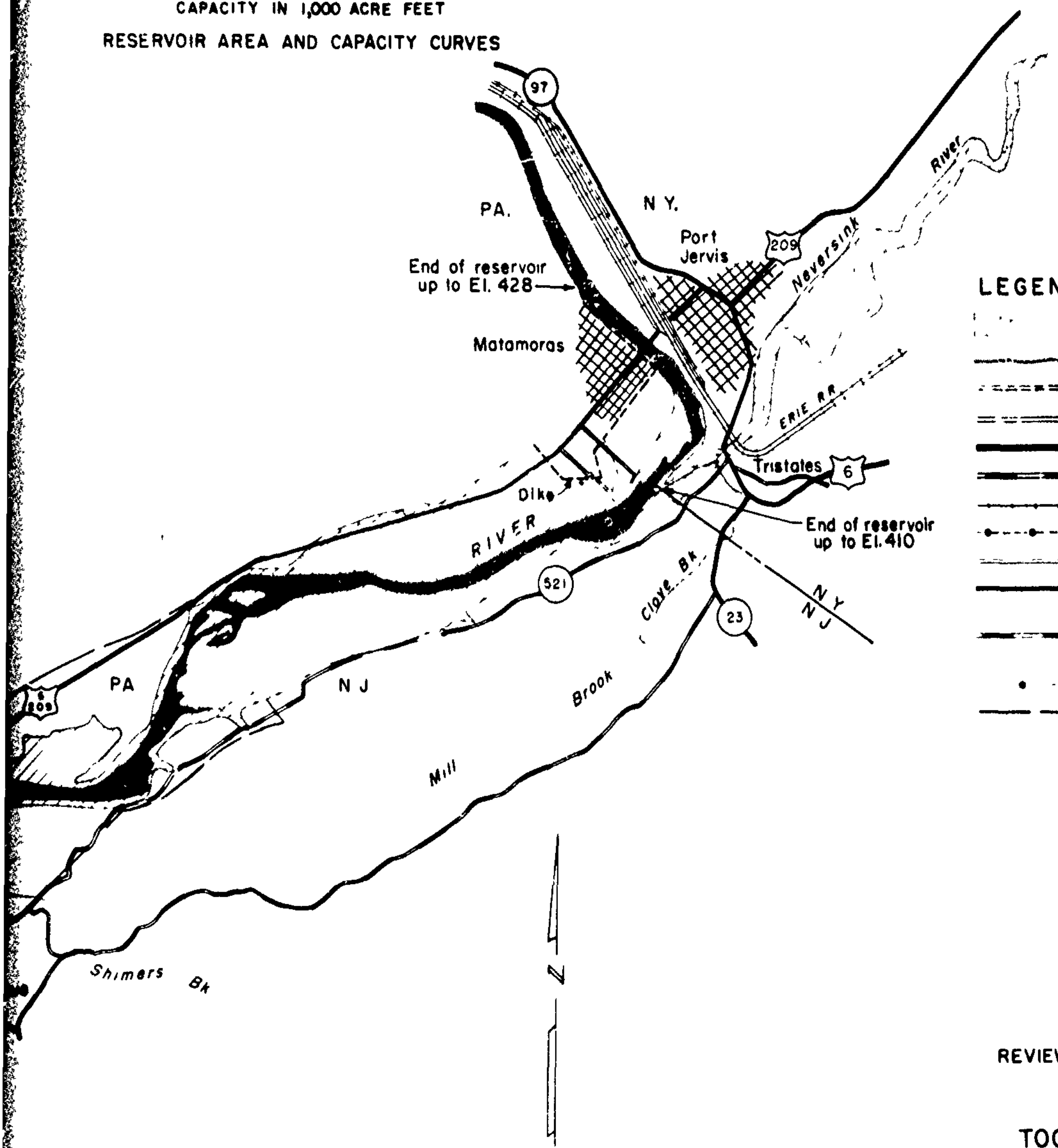


RESERVOIR AREA AND CAPACITY CURVES



LOCATION MAP

SCALE



LEGEND

- Multiple-Purpose Pool El 428
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Rebuilt Power Line
- Land Acquisition for Recreation Development

RESERVOIR MAP

1 ½ 0 1 MILE

REVIEW REPORT DELAWARE RIVER BASIN

TOCKS ISLAND RESERVOIR

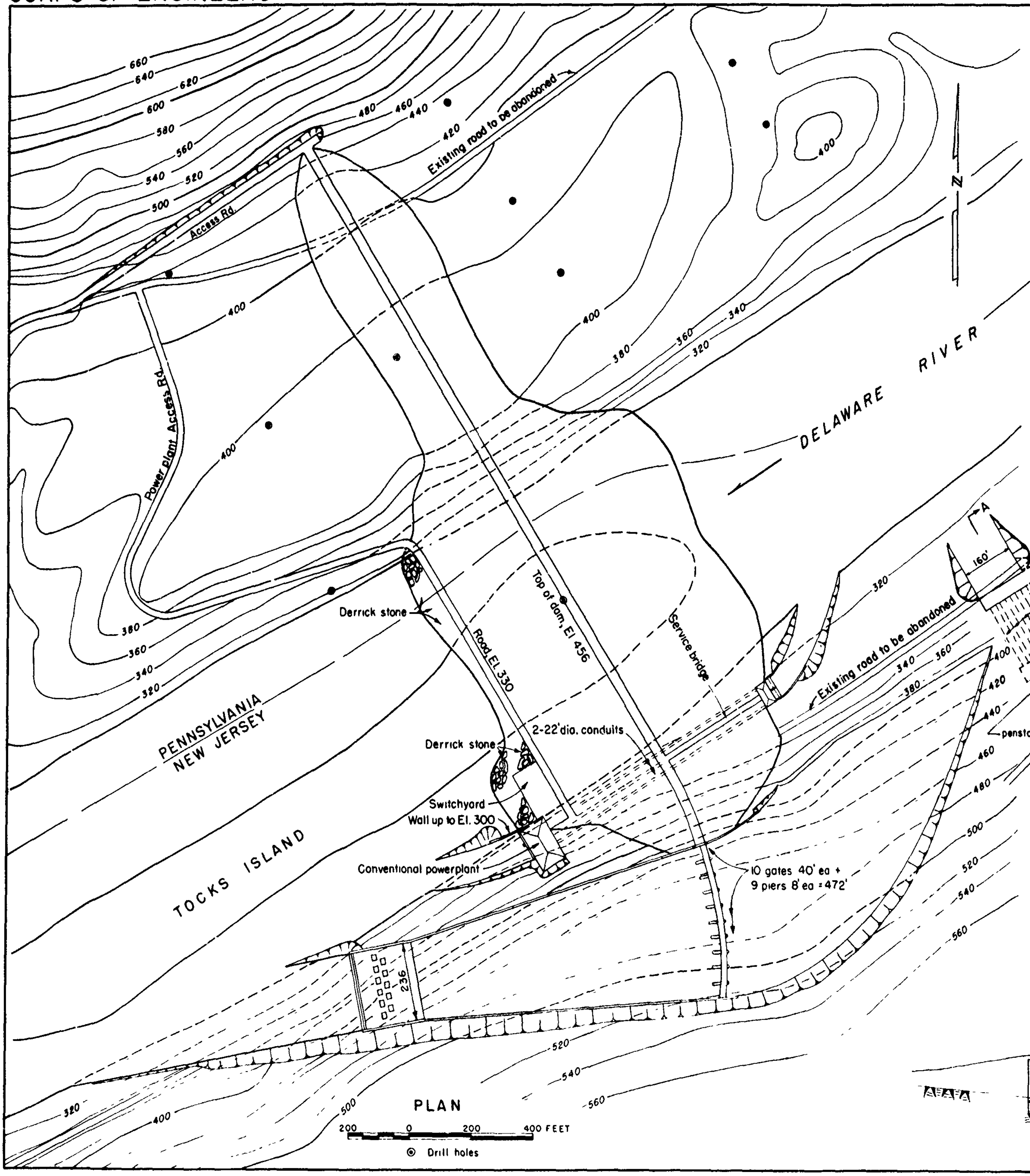
In 1 Sheet — Scale as Shown

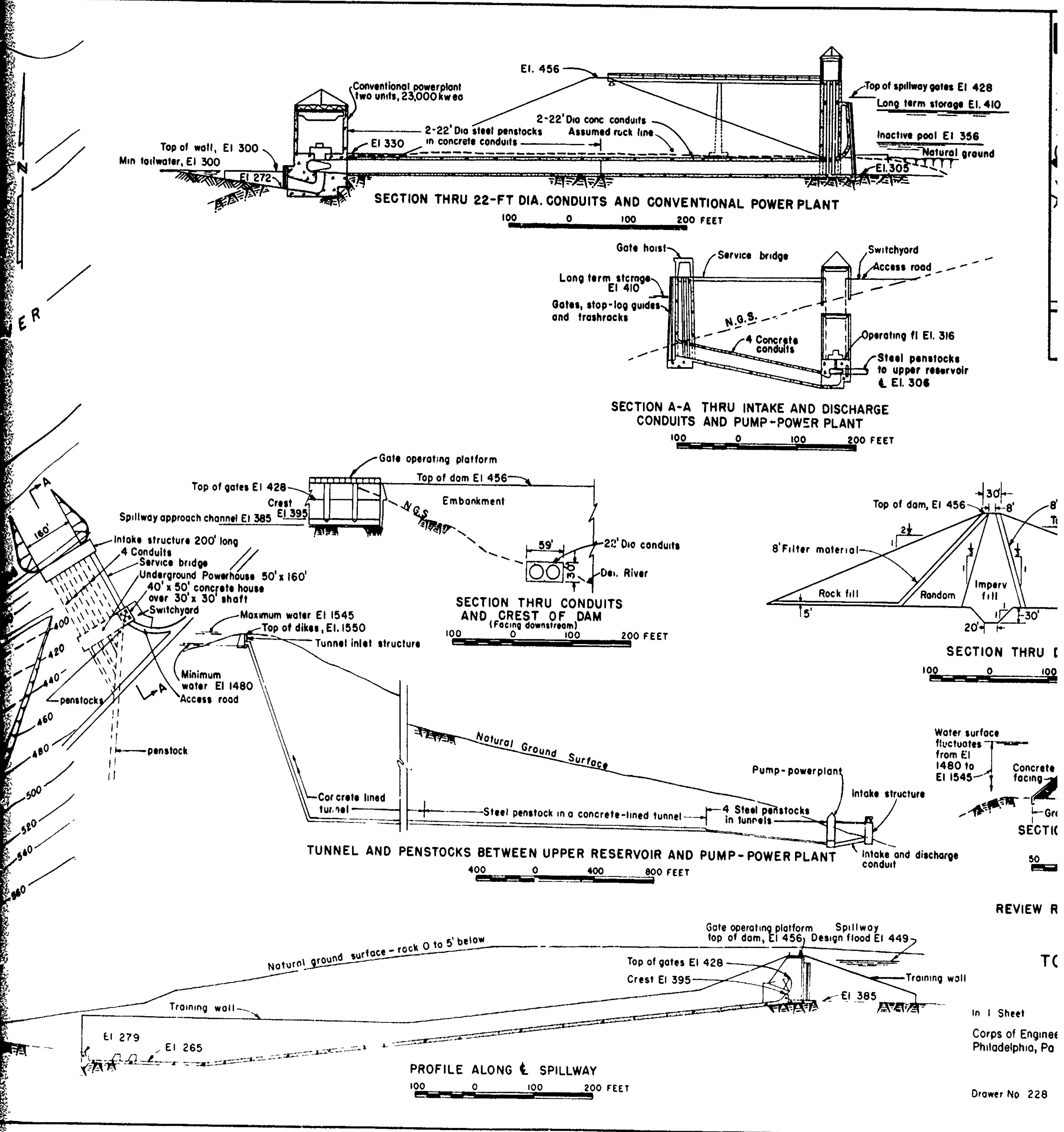
Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

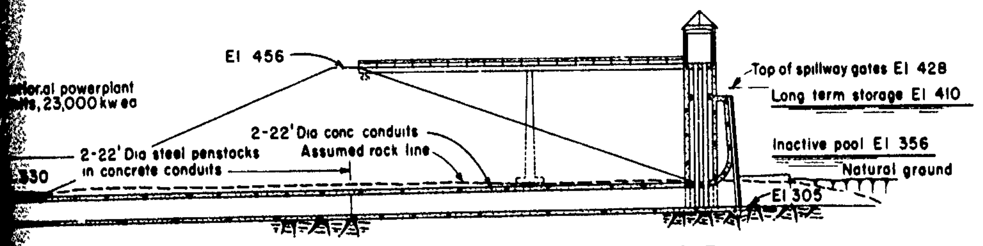
Drawer No 228 — File No 29099

CORPS OF ENGINEERS



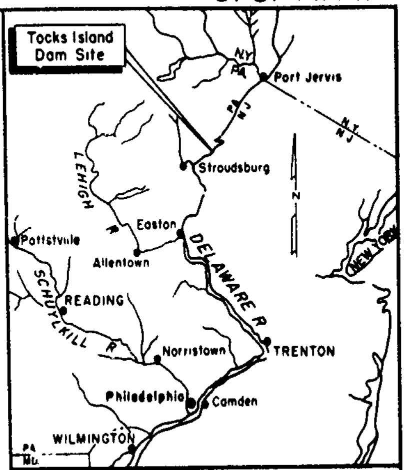


El. 456
Conventional powerplant two units, 23,000 kw ea
Top of spillway gates El 428
Long term storage El. 410
2-22' Dia conc conduits
Assumed rock line
2-22' Dia steel penstocks in concrete conduits
El 330
Inactive pool El 356
Natural ground
Top of wall, El 300
Min tailwater, El 300
El 272
El. 305
SECTION THRU 22-FT DIA. CONDUITS AND CONVENTIONAL POWER PLANT
100 0 100 200 FEET
Gate hoist
Service bridge
Switchyard
Access road
Long term storage El 410
Gates, stop-log guides and trashracks
N.G.S.
4 Concrete conduits
Operating fl El. 316
Steel penstocks to upper reservoir ℄ El. 306
SECTION A-A THRU INTAKE AND DISCHARGE CONDUITS AND PUMP-POWER PLANT
100 0 100 200 FEET
Gate operating platform
Top of gates El 428
Top of dam El 456
Crest El 395
Embankment
Spillway approach channel El 385
N.G.S.
59'
22' Dia conduits
30'
Del. River
SECTION THRU CONDUITS AND CREST OF DAM
(Facing downstream)
100 0 100 200 FEET
30'
Top of dam, El 456
8'
8'
8' Filter material
Rock fill
Random
Imperv fill
5'
20'
30'
SECTION THRU
100 0 100
160'
A
Intake structure 200' long
4 Conduits
Service bridge
Underground Powerhouse 50' x 160'
40' x 50' concrete house over 30' x 30' shaft
Switchyard
Maximum water El 1545
Top of dikes, El. 1550
Tunnel inlet structure
Minimum water El 1480
Access road
A
penstocks
penstock
400
420
440
460
480
500
520
540
560
N
ER
Natural Ground Surface
Concrete lined tunnel
Steel penstock in a concrete-lined tunnel
4 Steel penstocks in tunnels
Pump-powerplant
Intake structure
Intake and discharge conduit
TUNNEL AND PENSTOCKS BETWEEN UPPER RESERVOIR AND PUMP-POWER PLANT
400 0 400 800 FEET
Water surface fluctuates from El 1480 to El 1545
Concrete facing
SECTIO
50
REVIEW R
Gate operating platform top of dam, El 456
Spillway Design flood El 449
Natural ground surface - rock 0 to 5' below
Top of gates El 428
Crest El 395
Training wall
El 385
Training wall
El 279
El 265
PROFILE ALONG ℄ SPILLWAY
100 0 100 200 FEET
TO
In 1 Sheet
Corps of Engineers
Philadelphia, Pa
Drawer No 228



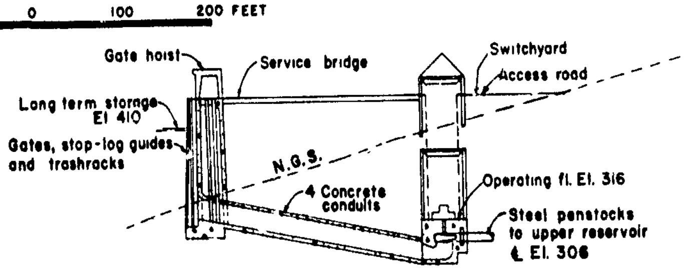
...ECTION THRU 22-FT. DIA. CONDUITS AND CONVENTIONAL POWER PLANT

100 0 100 200 FEET



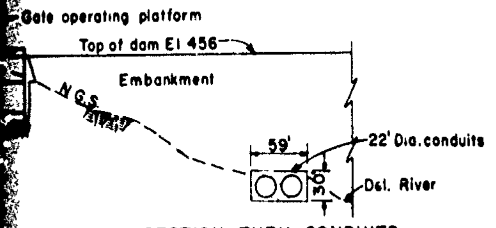
LOCATION MAP

SCALE



SECTION A-A THRU INTAKE AND DISCHARGE CONDUITS AND PUMP-POWER PLANT

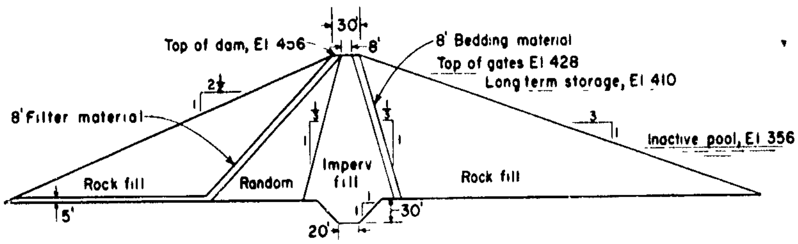
100 0 100 200 FEET



SECTION THRU CONDUITS AND CREST OF DAM
(Facing downstream)

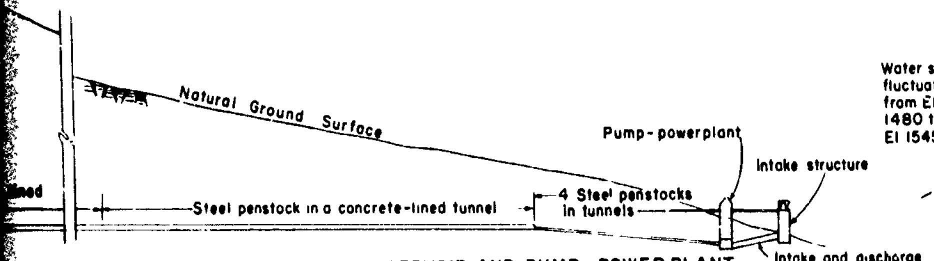
100 0 100 200 FEET

structure



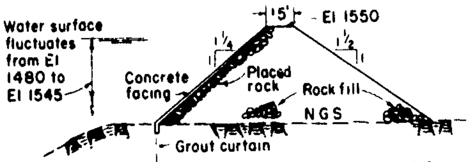
SECTION THRU DAM

100 0 100 200 FEET



...AND PENSTOCKS BETWEEN UPPER RESERVOIR AND PUMP-POWER PLANT

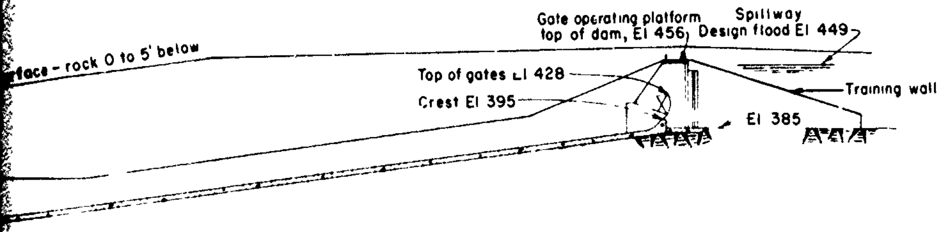
400 0 400 800 FEET



SECTION THRU DIKES AROUND UPPER RESERVOIR

50 0 50 100 FEET

REVIEW REPORT DELAWARE RIVER BASIN



PROFILE ALONG ℄ SPILLWAY

100 0 100 200 FEET

TOCKS ISLAND DAM

In 1 Sheet

Scales as Shown

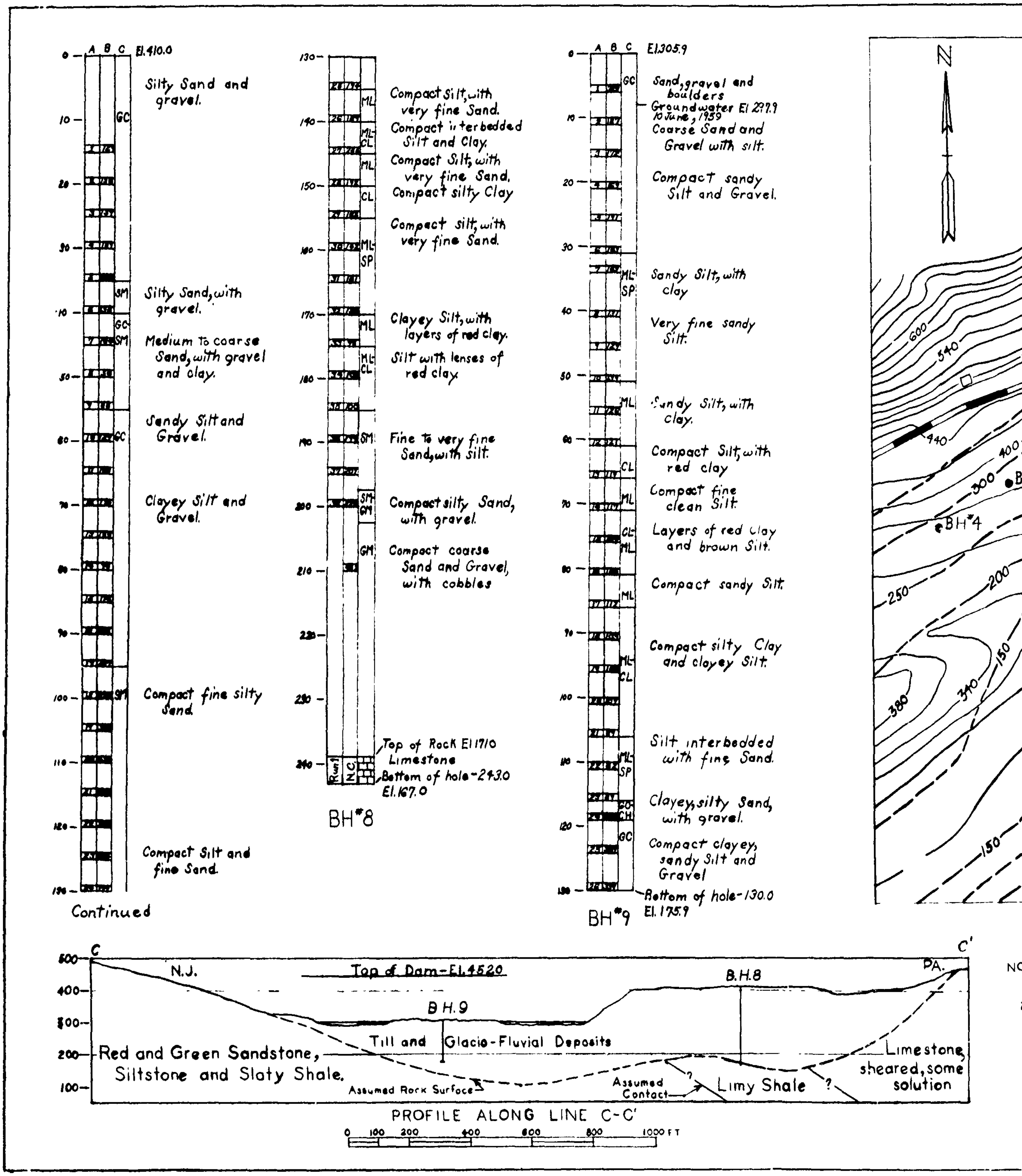
Corps of Engineers
Philadelphia, Pa

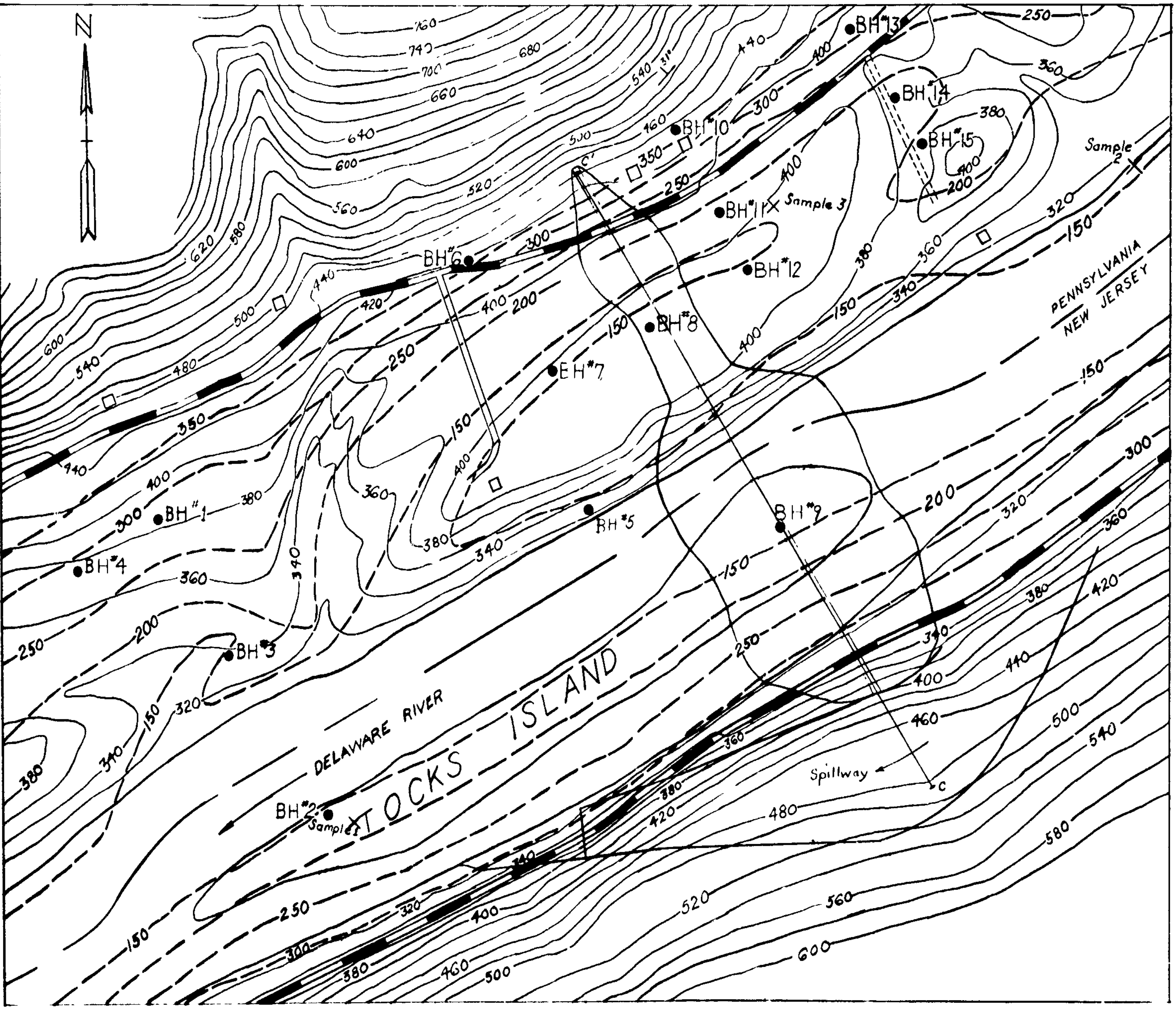
Philadelphia District
June 1960
Revised Oct 1960

Drawer No 228

File No 29098

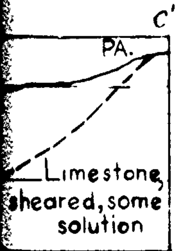
CORPS OF ENGINEERS





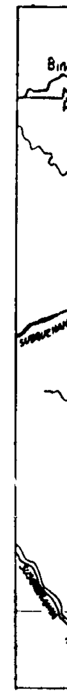
SITE MAP

0 100 200 500 1000 1500 FT



NOTES

1. Descriptions of materials encountered in borings are based on visual inspection of spoon and core samples
2. Column 'A' refers to the sample number or core run number
3. Column "B" refers to (a) the number of blows of a 140 lb hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered, or (b) the amount of core recovery, stated in percent, of a specified run of core barrel
4. Column "C" is a field classification of the materials encountered, using the Unified Soils Classification System symbols and graphic rock symbols
5. All sections face downstream
6. All elevations based on mean sea level datum
7. Logs of holes 6-7 and 10-15 shown on sheet no 29072
8. Logs of holes 1-5 shown on sheet no 29083.
9. Borings 1-4 by Battle Brothers Drilling Co, Aug - Oct 1958.
10. Boring 5 by New York Dist, Feb, 1946
11. Borings 6-15 by Sprague and Henwood, Inc Scranton Pa Apr - June 1958
12. represent contours on bedrock surface. Above 350 ft rock at, or close to surface



NOTE
13. Bo
Fo
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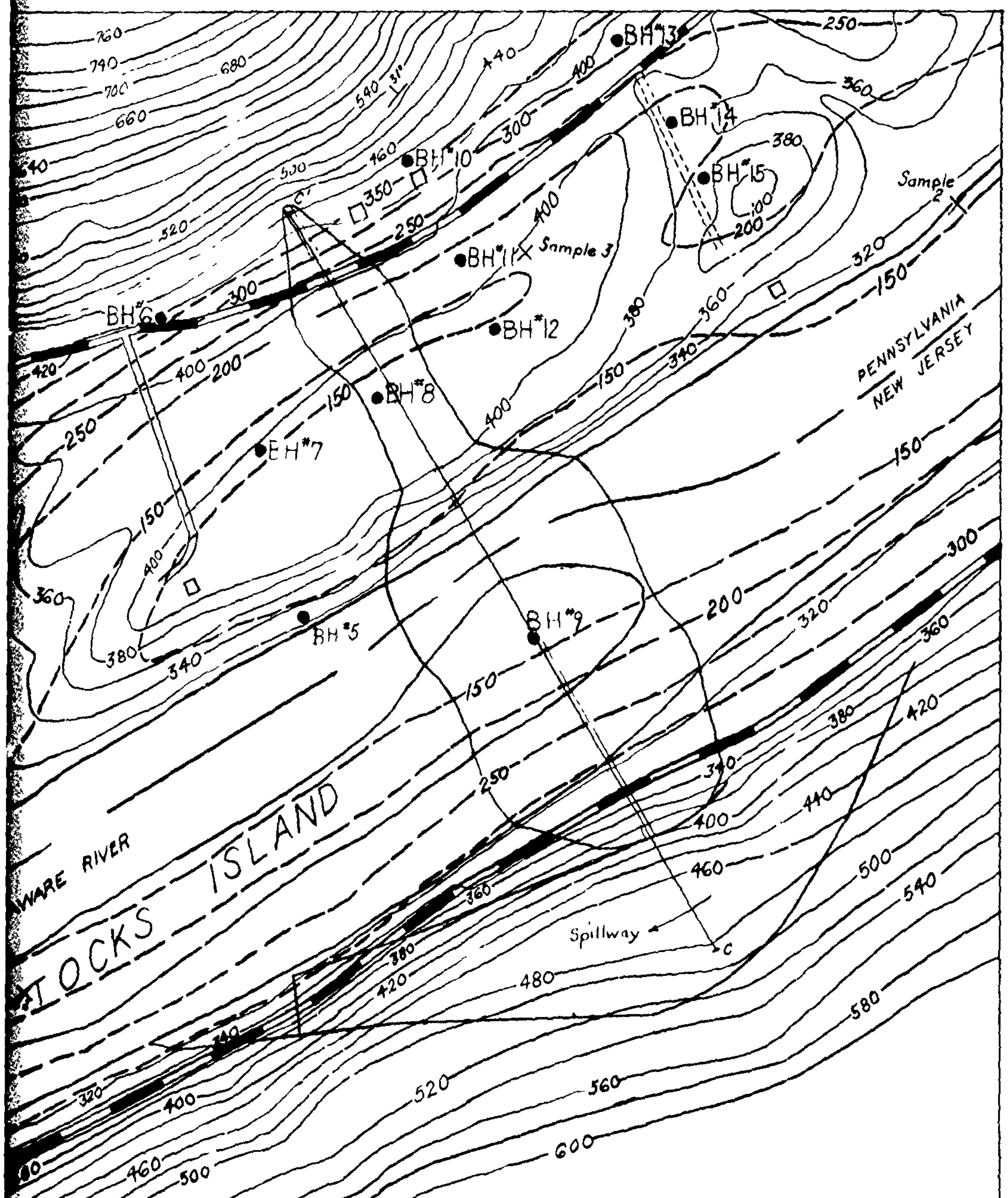
REVIEW REPO

TOCKS IS
GEOL

Sheet 1 of 3
Corps of Engineers
Philadelphia, Pa.

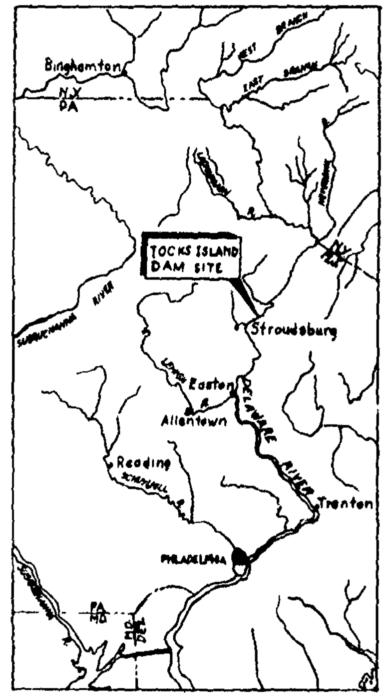
Drawer No 228

U.S. ARMY



SITE MAP

0 100 200 500 1000 1500 FT



LOCATION MAP

NOTES: (cont'd.)

13. Borings 8, 13, 14, and 15 drilled with Failing rig using mud. No water level obtained.

... encountered in borings are ... of spoon and core samples ... sample number or core run

... the number of blows of a 140 lb ... required to push the sampling ... the materials encountered, or (b) ... covery, stated in percent of ... barrel

... lassification of the materials ... Unified Soils Classifi- ... bols and graphic rock symbols

... nstream

6. All elevations based on mean sea level datum
7. Logs of holes 6-7 and 10-15 shown on sheet no 29072
8. Logs of holes 1-5 shown on sheet no 29083.
9. Boring 1-4 by Battle Brothers Drilling Co, Aug - Oct 1156.
10. Boring 5 by New York Dist, Feb, 1946
11. Borings 6-15 by Sprague and Henwood, Inc Scranton Pa, April - June 1958
12. represent contours on bedrock surface. Above 350 ft rock at, or close to surface

REVIEW REPORT DELAWARE RIVER BASIN

TOCKS ISLAND PROJECT
GEOLOGIC DATA

Sheet 1 of 3
Corps of Engineers
Philadelphia, Pa.

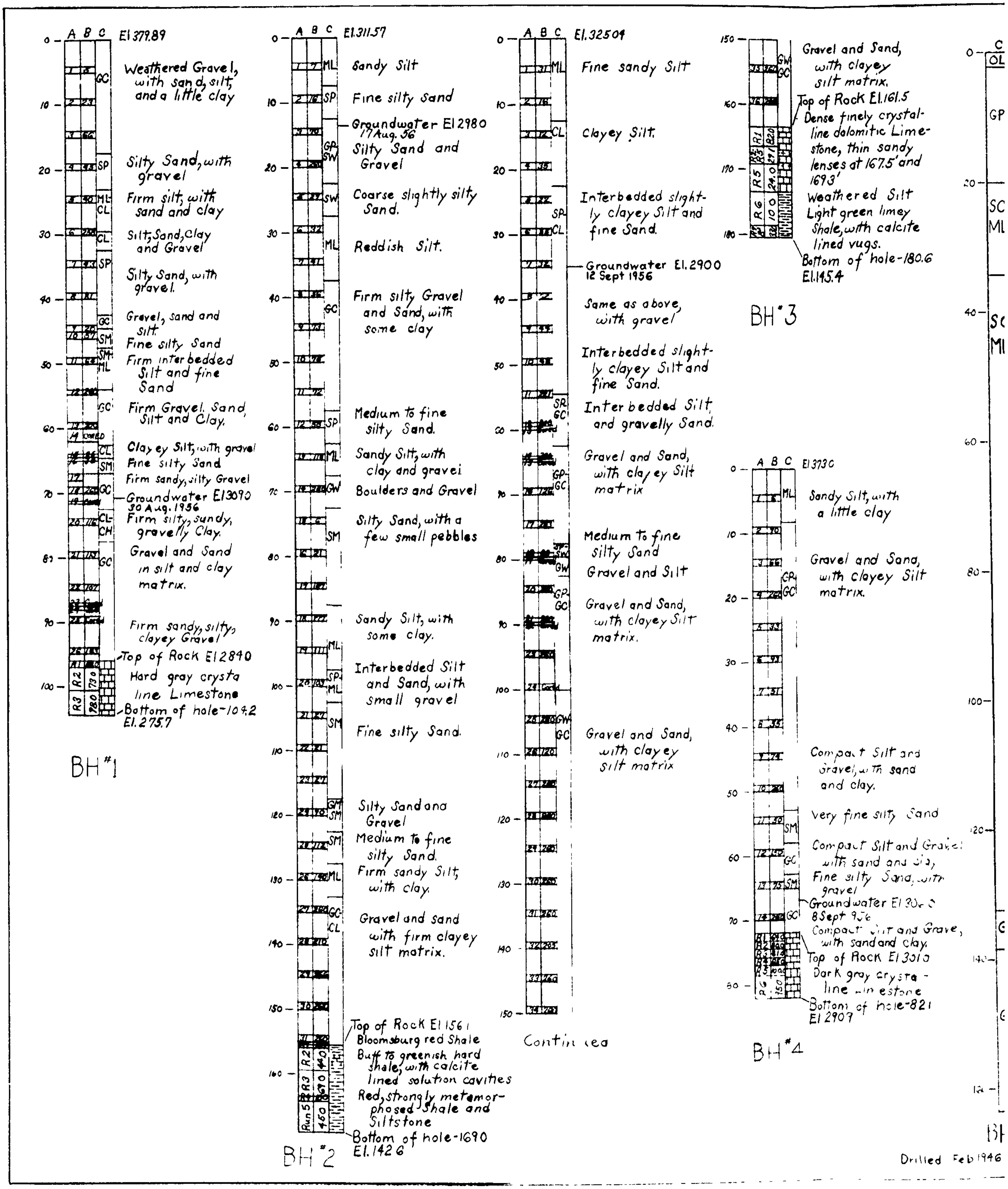
Scales as Shown
Philadelphia District
11 Jan 60

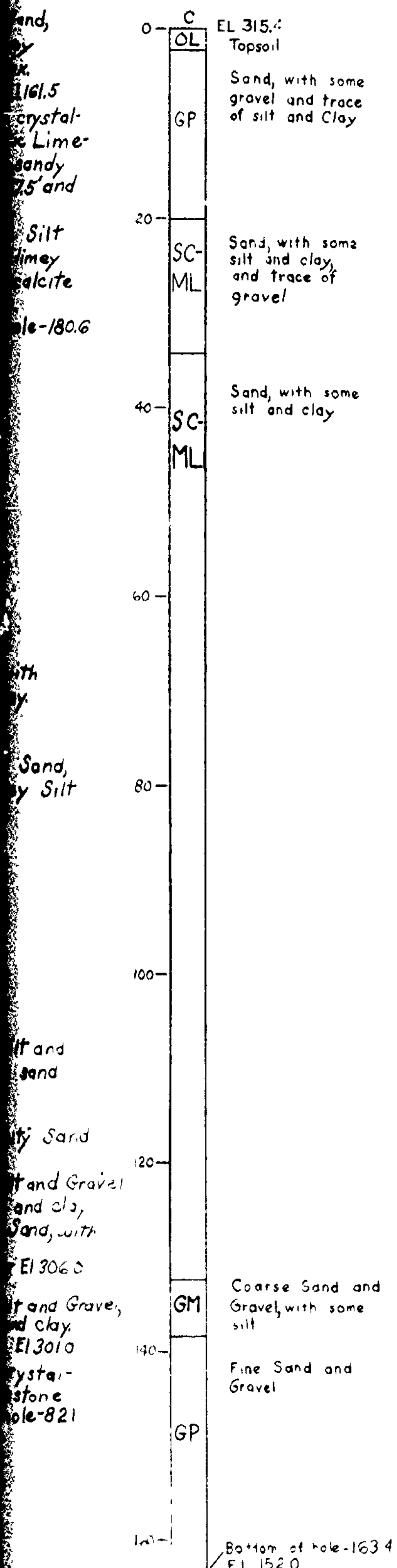
Drawer No. 228

File No 29076

PLATE 17

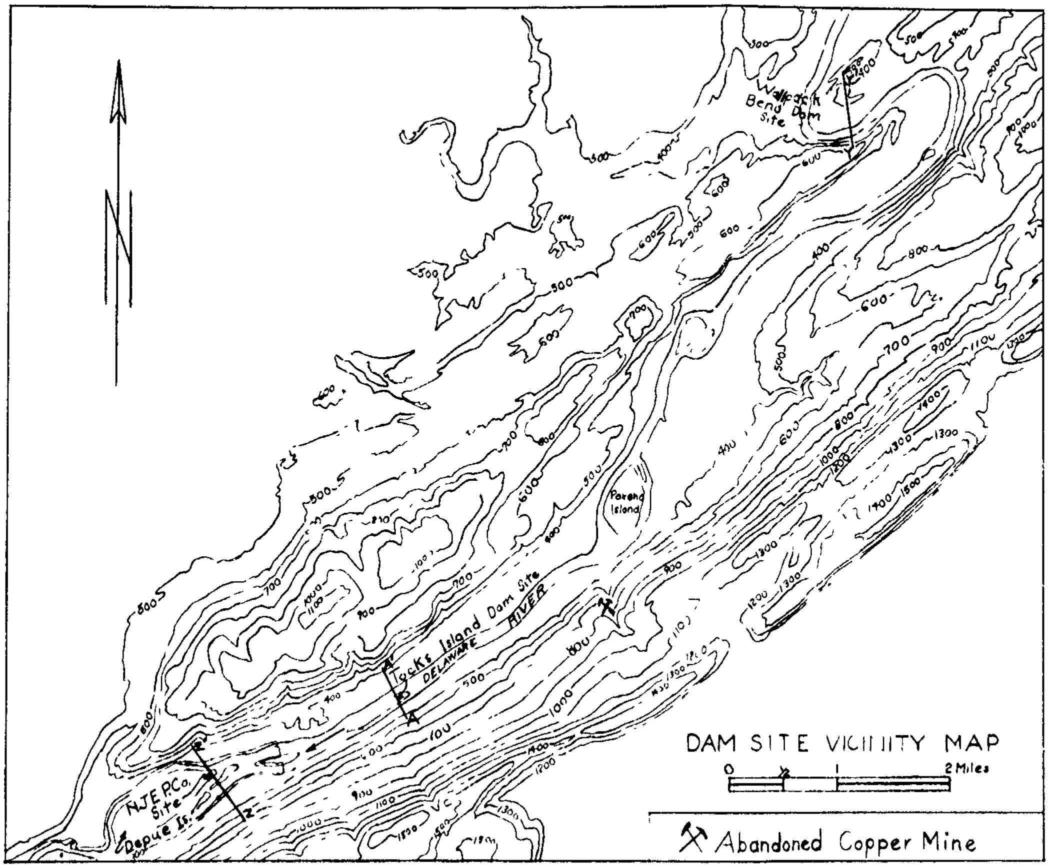
CORPS OF ENGINEERS

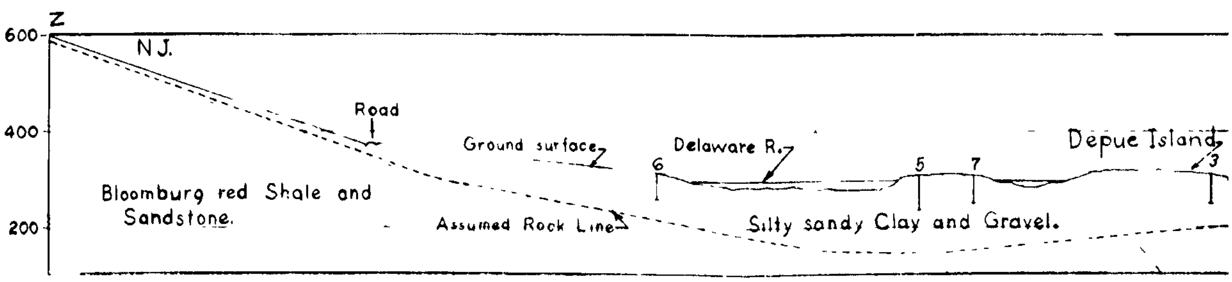




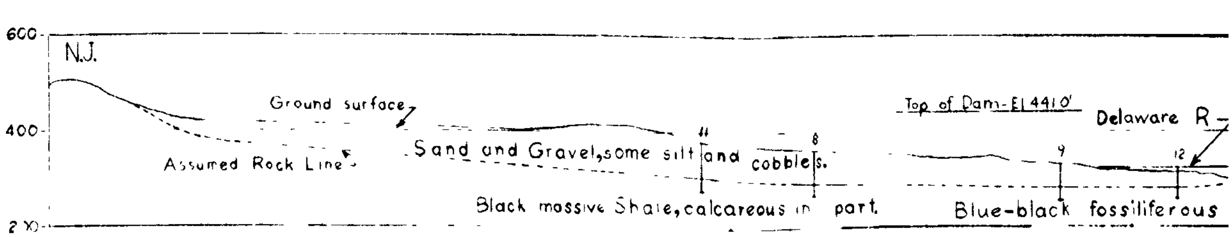
BH-5

Drilled Feb 1946 as No 1 by N.Y Dist, Corps of Engineers

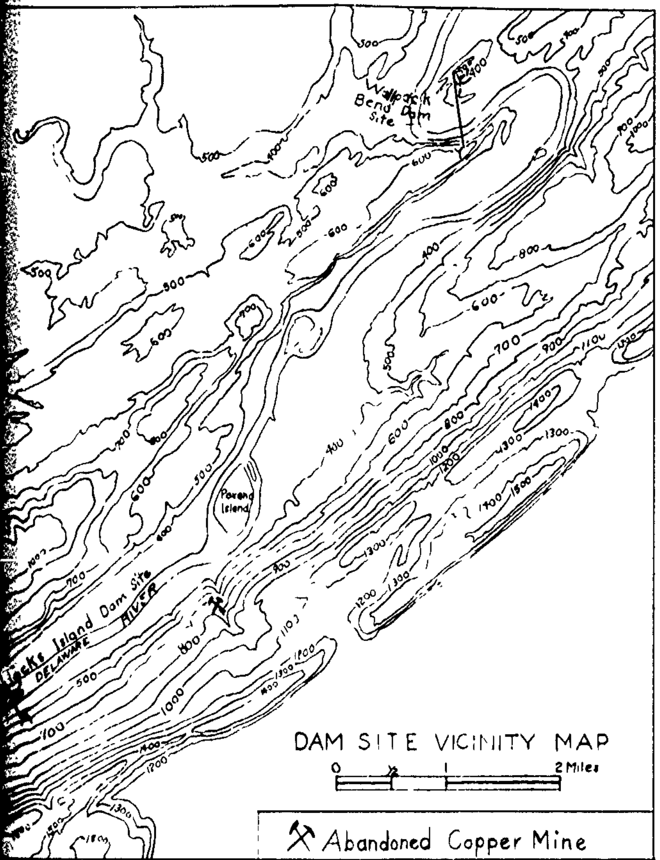


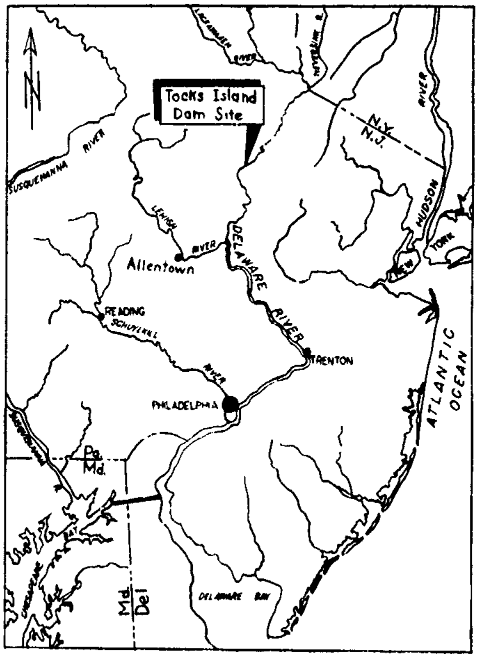


PROFILE ALONG AXIS OF NEW JERSEY ELECTRIC POW



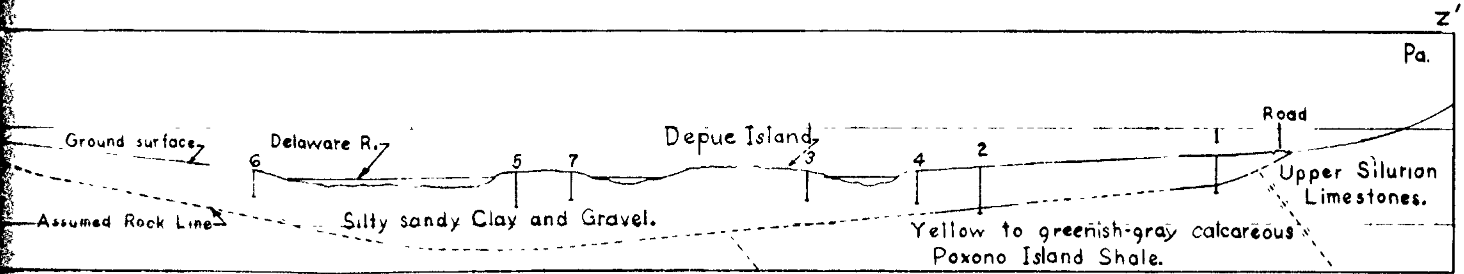
PROFILE ALONG AXIS OF WALLPACK BEND SITE





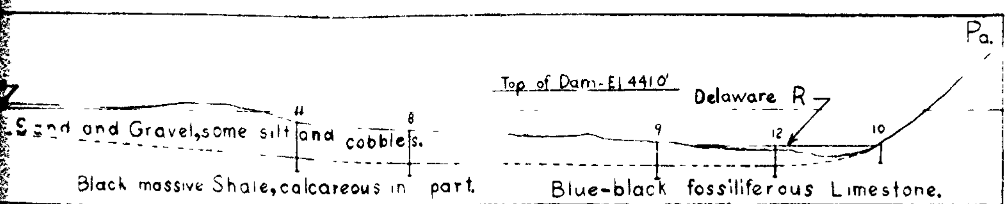
LOCATION MAP

NOTES may be seen on sheet no. 29076.



PROFILE ALONG AXIS OF NEW JERSEY ELECTRIC POWER Co. SITE

0 100 200 400 600 800 1000 FT.



PROFILE ALONG AXIS OF WALLPACK BEND SITE

0 100 200 400 600 800 1000 FT.

REVIEW REPORT DELAWARE RIVER BASIN

TOCKS ISLAND PROJECT
GEOLOGIC DATA

Sheet 2 of 3
Corps of Engineers
Philadelphia, Pa

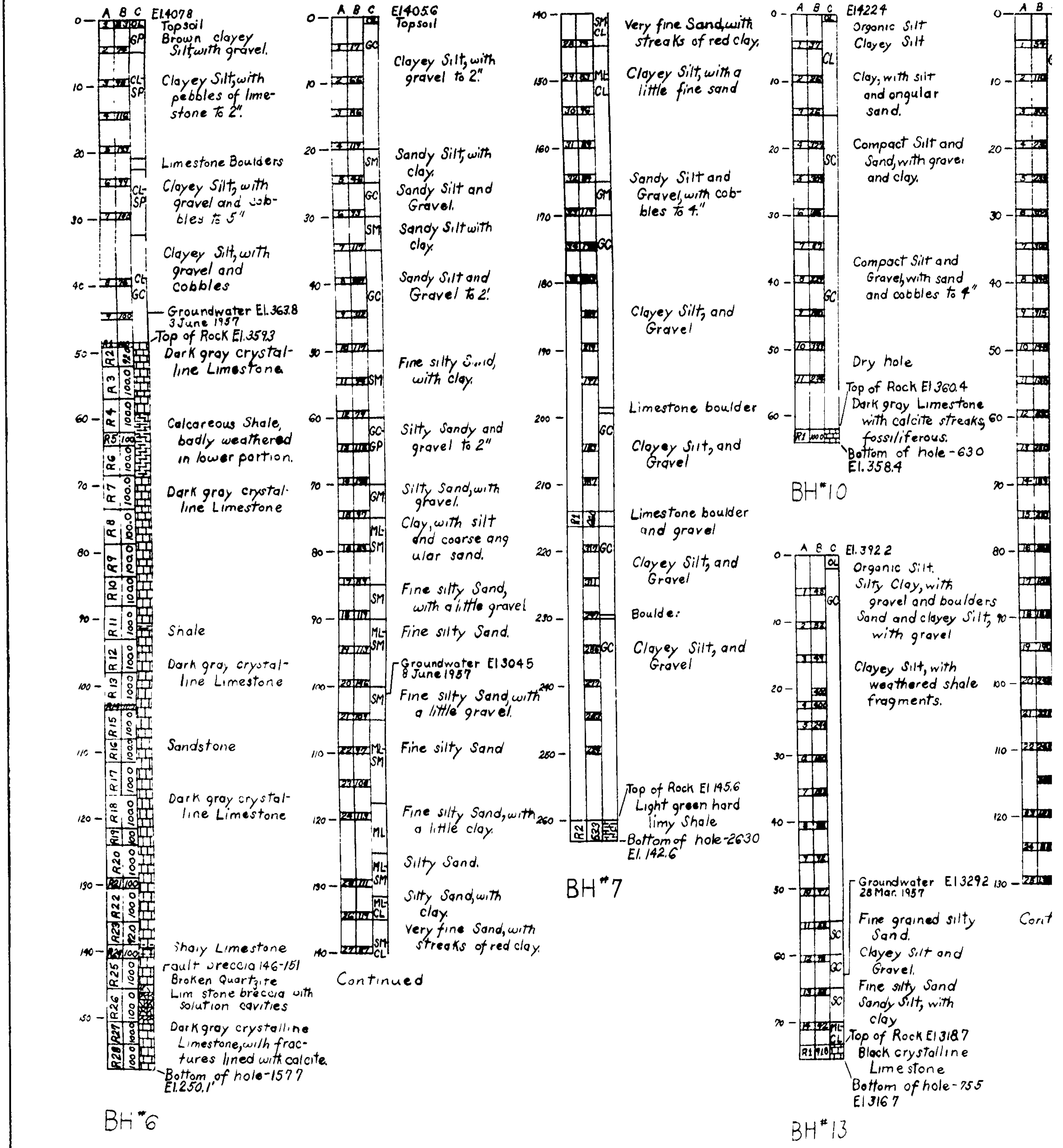
Scales as Shown
Philadelphia District
11 Jan 60

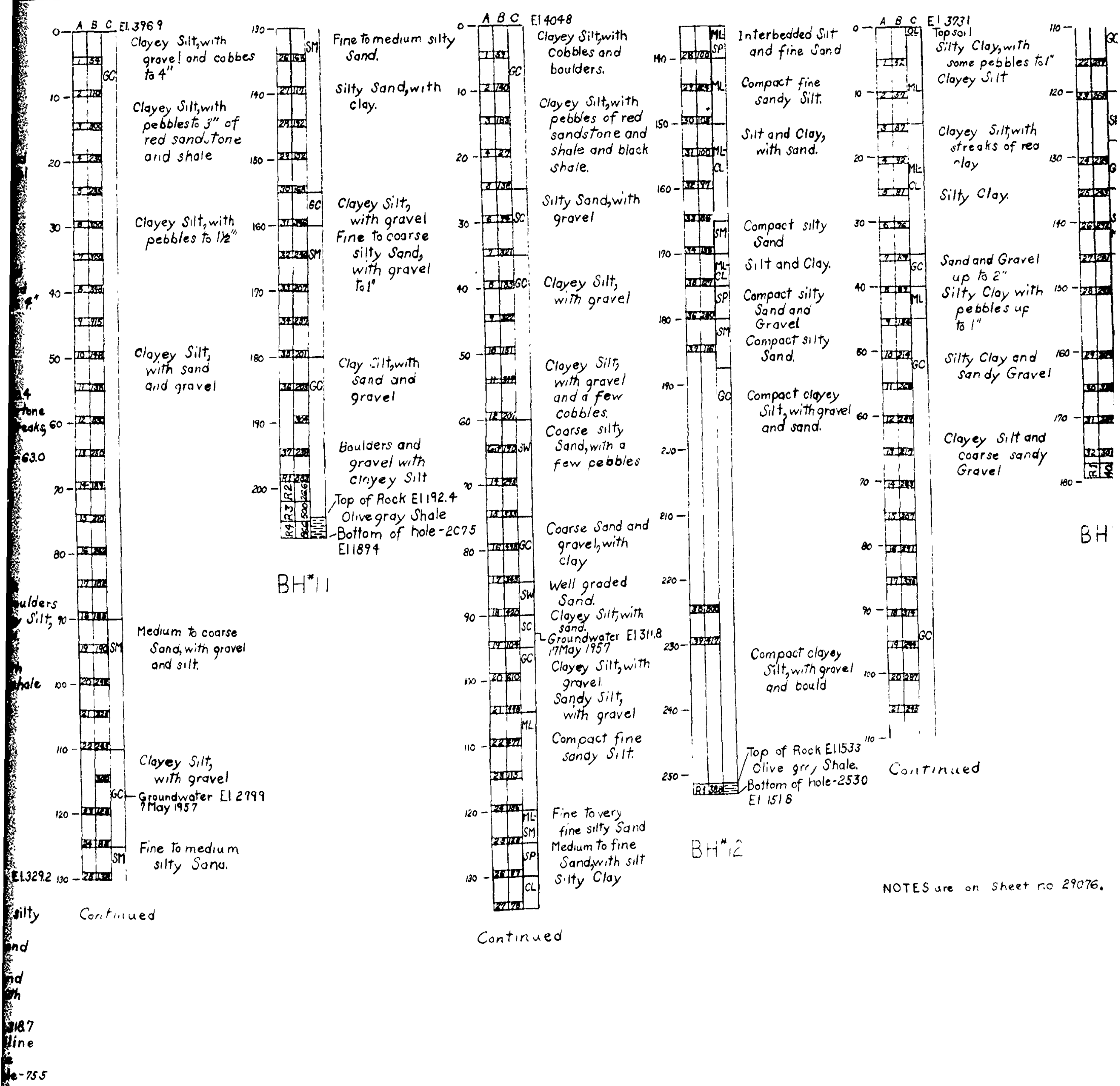
Drawer No 228

File No 29083

PLATE 18

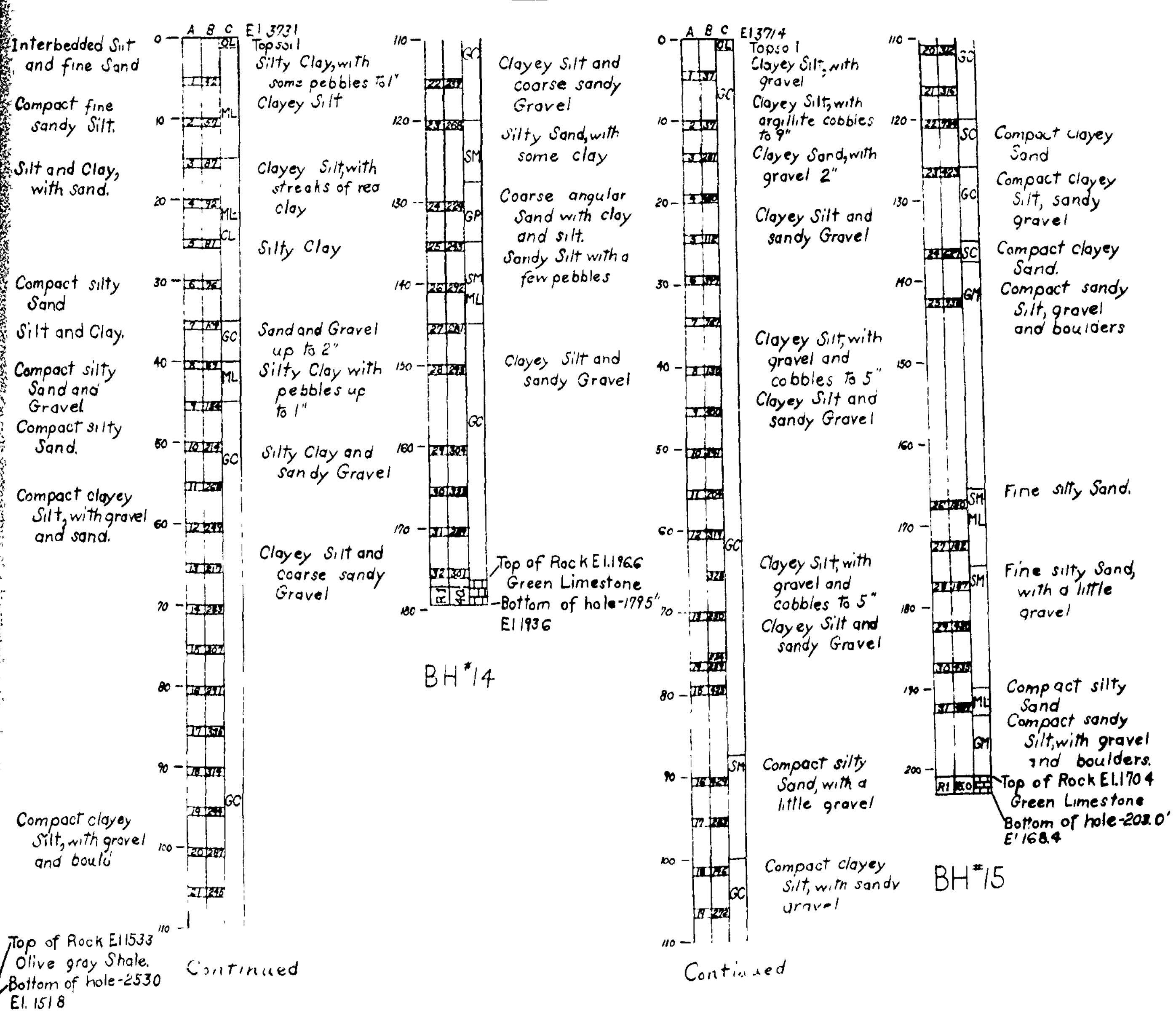
CORPS OF ENGINEERS





A B C El. 396.9
Clayey Silt, with gravel and cobbles to 4"
GC
Clayey Silt, with pebbles to 3" of red sandstone and shale
Clayey Silt, with pebbles to 1½"
Clayey Silt, with sand and gravel
Medium to coarse Sand, with gravel and silt.
SM
Clayey Silt, with gravel
GC
Groundwater El. 279.9 7 May 1957
Fine to medium silty Sand.
SM
El. 329.2
Continued
Fine to medium silty Sand.
SM
Silty Sand, with clay.
Clayey Silt, with gravel
GC
Fine to coarse silty Sand, with gravel to 1"
SM
Clay Silt, with sand and gravel
GC
Boulders and gravel with clayey Silt
Top of Rock El 192.4
Olive gray Shale
Bottom of hole - 207.5
El 189.4
BH#11
A B C El 404.8
Clayey Silt, with Cobbles and boulders.
GC
Clayey Silt, with pebbles of red sandstone and shale and black shale.
Silty Sand, with gravel
SC
Clayey Silt, with gravel
GC
Clayey Silt, with gravel and a few cobbles.
Coarse silty Sand, with a few pebbles
SW
Coarse Sand and gravel, with clay
GC
Well graded Sand.
SW
Clayey Silt, with sand.
SC
Groundwater El 311.8 17 May 1957
Clayey Silt, with gravel.
GC
Sandy Silt, with gravel
ML
Compact fine sandy Silt.
Fine to very fine silty Sand
ML
SM
Medium to fine Sand, with silt
SP
Silty Clay
CL
Continued
Interbedded Silt and fine Sand
ML
SP
Compact fine sandy Silt.
ML
Silt and Clay, with sand.
ML-CL
Compact silty Sand
SM
Silt and Clay.
ML-CL
Compact silty Sand and Gravel
SP
Compact silty Sand.
SM
Compact clayey Silt, with gravel and sand.
GC
Compact clayey Silt, with gravel and bould
Top of Rock El 153.3
Olive grey Shale.
Bottom of hole - 253.0
El 151.8
BH#12
A B C El 373.1
Top soil
OL
Silty Clay, with some pebbles to 1"
Clayey Silt
ML
Clayey Silt, with streaks of red clay
ML-CL
Silty Clay.
Sand and Gravel up to 2"
GC
Silty Clay with pebbles up to 1"
ML
Silty Clay and sandy Gravel
GC
Clayey Silt and coarse sandy Gravel
GC
Continued
BH
NOTES are on Sheet no 29076.

U.S. ARMY



NOTES are on Sheet no 29076.

REVIEW REPORT DELAWARE RIVER BASIN

TOCKS ISLAND PROJECT
GEOLOGIC DATA

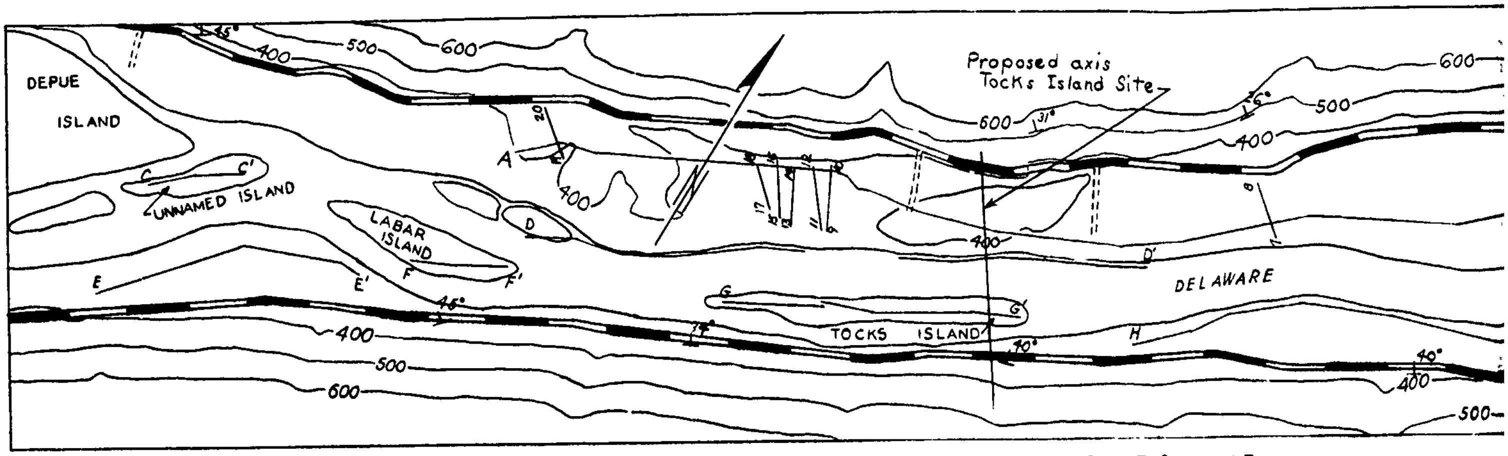
Sheet 2 of 3
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
12 Jan 60

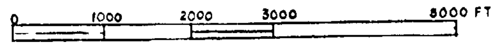
Drawer No 228

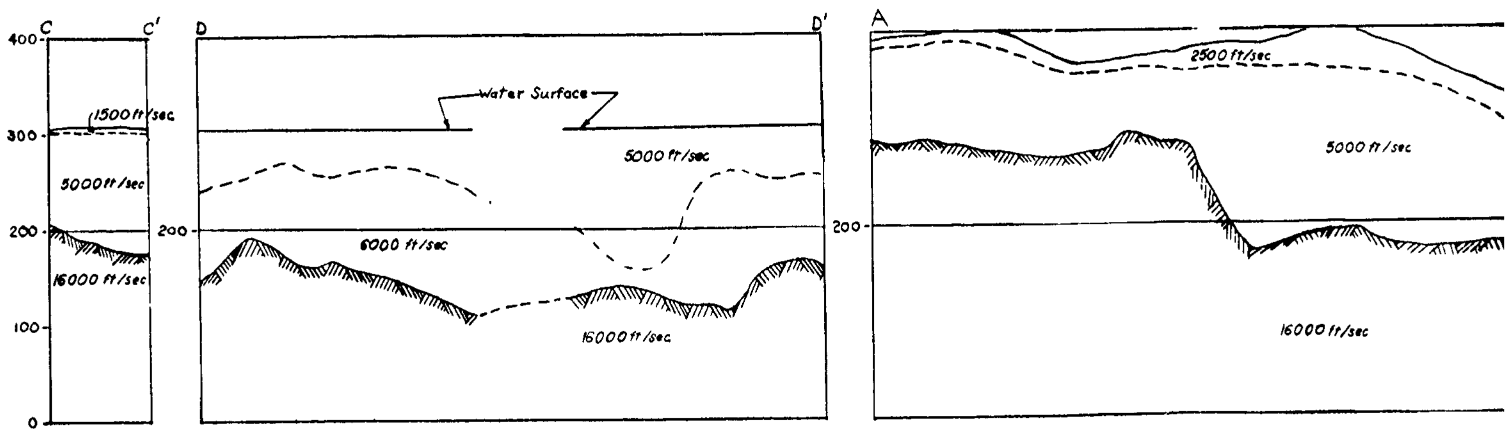
File No 29077

CORPS OF ENGINEERS

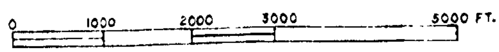


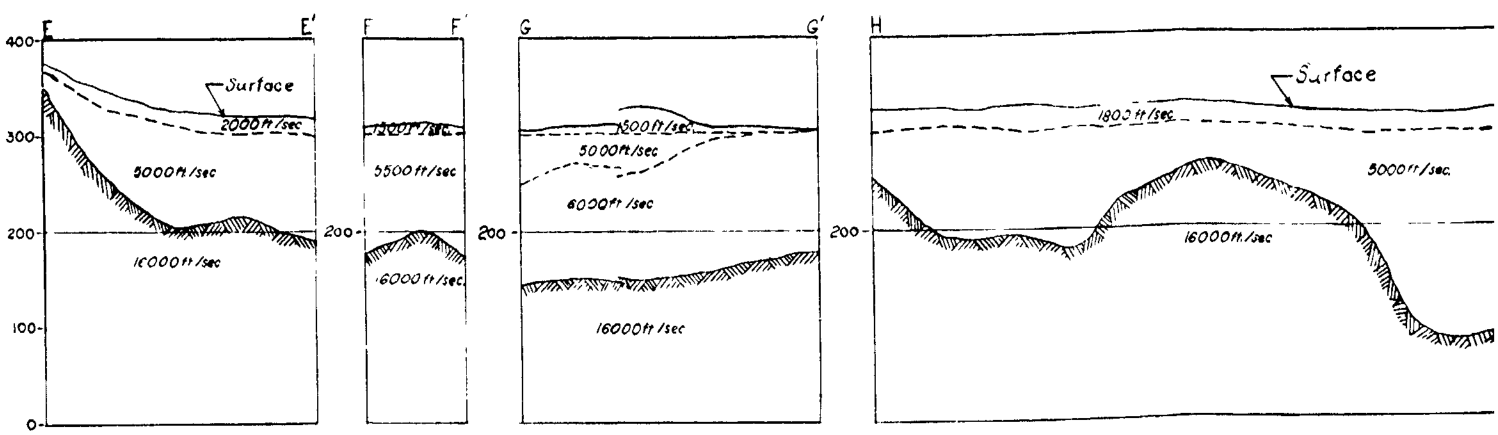
LOCATION MAP

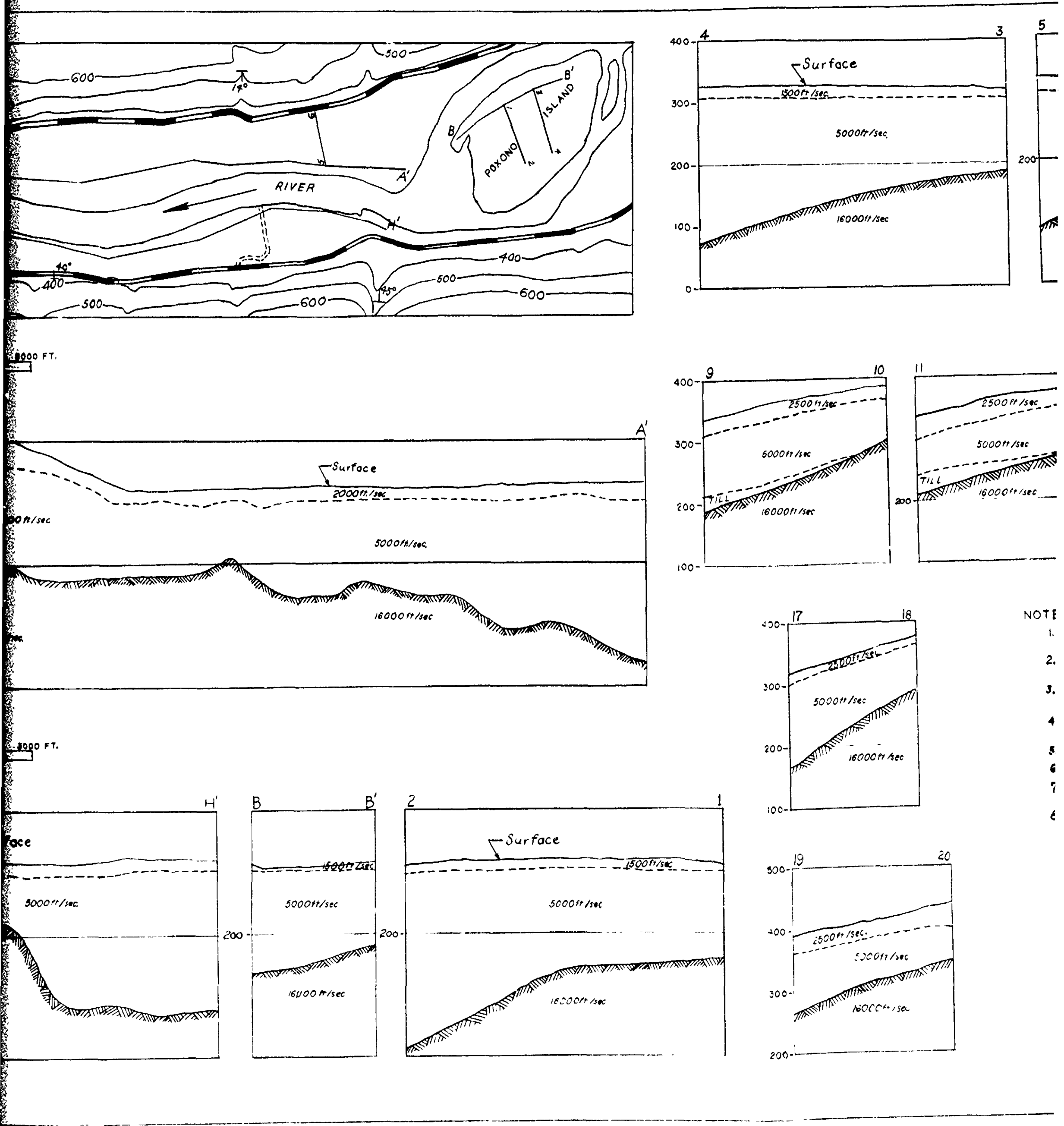




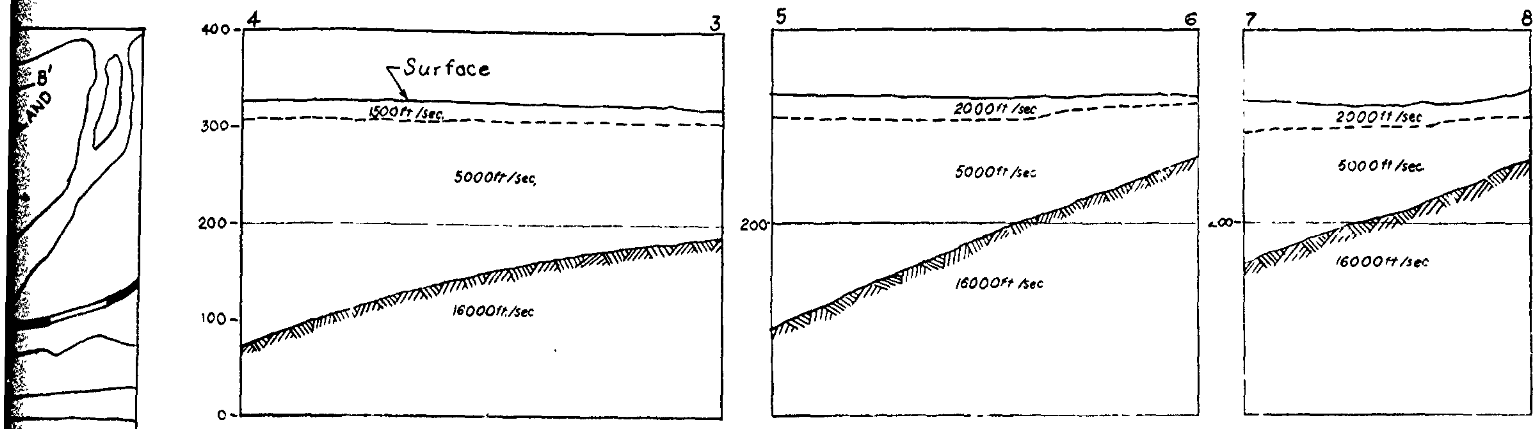
SEISMIC PROFILES





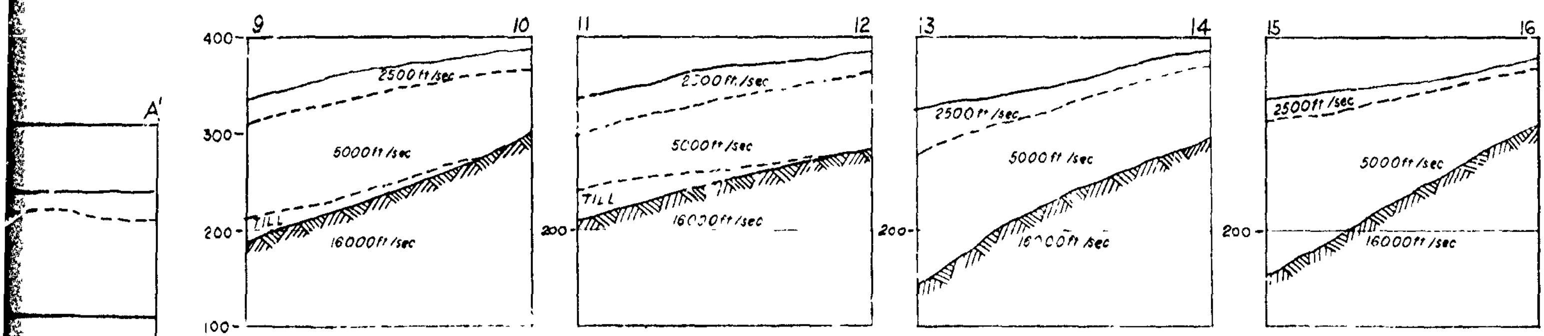


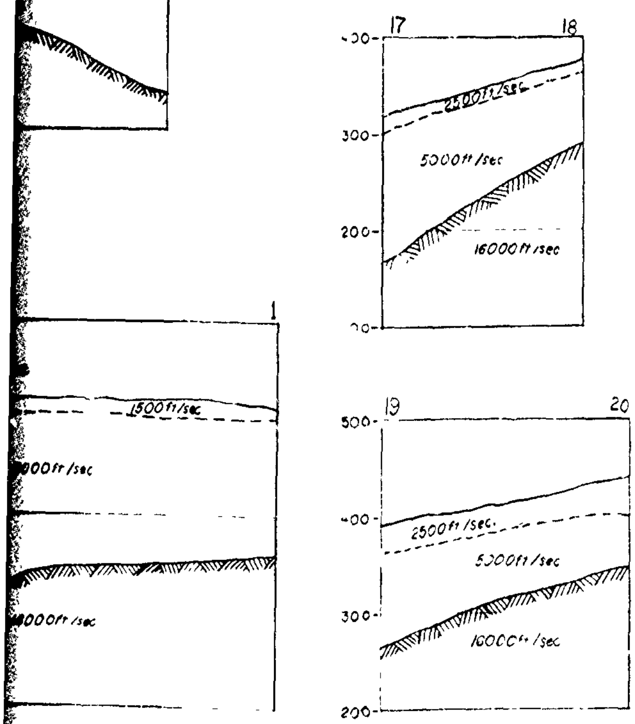
600
500
400
600
500
600
500
400
17°
40°
45°
B
B'
POXONO
ISLAND
A'
RIVER
H'
3000 FT.
4
3
Surface
1500 ft/sec
5000 ft/sec
16000 ft/sec
5
9
10
2500 ft/sec
5000 ft/sec
TILL
16000 ft/sec
11
2500 ft/sec
5000 ft/sec
TILL
16000 ft/sec
A'
Surface
2000 ft/sec
5000 ft/sec
16000 ft/sec
3000 FT.
17
18
2500 ft/sec
5000 ft/sec
16000 ft/sec
NOTE
H'
Surface
5000 ft/sec
B
B'
1500 ft/sec
5000 ft/sec
16000 ft/sec
2
1
Surface
1500 ft/sec
5000 ft/sec
16000 ft/sec
19
20
2500 ft/sec
5000 ft/sec
16000 ft/sec



SEISMIC PROFILES

0 100 200 300 400 500 FT.





NOTES.

1. Lettered profiles have a horizontal scale of 1 in = 2000 ft, and numbered profiles have a horizontal scale of 1 in = 400 ft
2. Velocities between 1500 to 2500 ft/sec indicates dry silt and/or sand (above water table).
3. Velocities of 5000 and 6000 ft/sec indicates moist silt and clay or wet sands and gravels (below water table)
4. Hachured area with velocities of 16000 ft/sec indicates bedrock.
5. Profile D-D is an underwater seismic survey cross section
6. All elevations based on mean sea level datum
7. Seismic survey by Gahagan Dredging Corp, New York 4, N.Y., 1956
8. $\overset{40}{\curlyvee}$ - indicates direction of strike and dip of bed in degrees.

REVIEW REPORT DELAWARE RIVER BASIN

TOCKS ISLAND PROJECT
SEISMIC SURVEY DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
12 Jan 60

Drawer No 228

File No. 29080

30. Trexler Project.

a. Trexler dam, as proposed, would be located across the valley of Jordan Creek in the Trexler, Pennsylvania State Game preserve about 1/2 mile downstream from the mouth of Mill Creek and about 8 miles northwest of Allentown, Pennsylvania. The drainage area above this site is 51 square miles. Data on basic dimensions of the projectare as follows:

Capacities

Long term, 25,000 ac.-ft., stream bed to elevation 479
Short term, 14,000 ac.-ft., between elevation 479 and elevation 492

Elevations

Top of dam, 508	Outlet, upstream invert, 400
Spillway crest, 492	Stream bed at dam, 395

Areas

Reservoir at elevation 479, 880 acres
Reservoir at elevation 492, 1,200 acres

b. At the dam site, Jordan Creek flows in a narrow valley with no flood plain. The right (east) valley wall rises steeply whereas the left wall rises at about a 4:1 slope. Bedrock of the Ordovician Martinsburg shale is exposed on the right abutment and is covered, on the left abutment, by a thin layer (probably 3 to 10 feet thick) of yellowish clay soil containing a considerable amount of black slaty shale fragments. Because of the numerous outcrops of rock in the area, no exploratory holes were drilled.

c. The dam proposed for this site would be a concrete gravity type structure 800 feet long, rising 113 feet above the creekbed. Flood waters would pass over a spillway section 200 feet long in the dam with a crest 97 feet above the creek. Conduits through the dam with regulating gates would permit release of reservoir water at a low level. Diversion during construction would be made over concrete monoliths left low for that purpose. Coarse aggregate for concrete could be secured from limestone quarries 5 to 5½ miles to the east and southeast of the site by highway. There is a possibility that, after testing, the fine screenings from these quarries would prove acceptable as fine aggregate. If this source could not be used the fine aggregate would have to be obtained from sand pits approximately 50 miles distant.

d. The reservoir to be created by this dam, up to elevation 492, would extend about 8 miles up Jordan Creek with "fingers" extending about 3 miles up Lyon Creek and 2 miles up Mill Creek. This reservoir would make it necessary to build fills and bridges to carry U. S. route 309 across the reservoir, to relocate other roads and the communities of Lyon Valley and Weidasville. There are no commercially valuable mineral deposits in the reservoir area.

TABLE U-9
TREXLER PROJECT COST ESTIMATE

Description	Estimated Cost
Lands and Damages	$ 811,000
Relocations	663,000
Reservoir Clearing	111,000
Dam & Appurtenant Works	5,636,000
Fish & Wildlife, Mitigation of Losses 1/	-
Access Road	75,000
Recreation 2/	2,638,000
Buildings, Grounds, Utilities	31,000
Engineering & Design	587,000
Supervision & Administration	652,000
TOTAL PROJECT COST	11,204,000

1/ Appendix J contains means of mitigating losses to stream fisheries, game habitat, and public hunting expected to be caused by the project. These means include habitat improvement and development of public hunting opportunity on 1,500 acres of land needed in Lehigh County, Pennsylvania. The cost required to provide these mitigations is a project cost, and while omitted from the estimate above is taken into account in the economic analyses in Appendix V.

2/ This cost includes engineering, design, supervision, and administration.

TABLE U-9
TREXLER PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and severance, 960 ac.	Job	L.S.	-	$184,000
Improvements, 43 units	Job	L.S.	-	398,000
Resettlement, 43 units	Job	L.S.	-	27,000
Easement, 330 ac.	Job	L.S.	-	47,000
Easement, improvements, 28 units	Job	L.S.	-	18,000
Contingencies, approx. 15%				102,000
Acquisition				35,000
		Total - Lands and Damages		811,000
Relocations				
New and improved state and county roads	mile	$125,000	1	$125,000
Culverts, including fills (3)	job	L.S.	-	400,000
Relocate service pole lines	mile	5,000	1	5,000
Contingencies, approx. 25%				133,000
		Total - Relocations		663,000
Engineering and Design				60,000
Supervision and Administration				66,000

TABLE U-9
TREXLER PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing				
Agricultural Land	acres	@ $ 80	280	$ 22,000
Woodland, light clearing	"	@ 80	630	50,000
Creek bed	"	@ -	35	-
Bldg. lots, etc.	"	@ 50	15	1,000
Farm units	each	@ 500	28	14,000
Dwellings	"	@ 80	16	1,000
Com'l. bldg. & school	"	@ 400	2	1,000
Contingencies, approx. 25%				22,000
	Total - Reservoir clearing			111,000
Engineering and Design				10,000
Supervision and Administration				11,000

TABLE U-9
TREXLER PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works				
Clearing & grubbing	acre	$600.00	2	$ 1,000
Diversion & care of stream	job	L.S.	-	100,000
Stripping for dam	c.y.	0.80	10,000	8,000
Excavation, common	c.y.	0.80	10,000	8,000
Excavation, rock	c.y.	5.00	58,000	290,000
Haul & disposal of waste material	c.y.	0.90	50,000	45,000
Foundation preparation	s.y.	7.00	7,000	49,000
Backfill	c.y.	1.20	11,000	13,000
Line drilling	s.f.	4.00	10,000	40,000
Drilling & pressure grouting	l.f.	9.00	3,000	27,000
Drilling drain and anchor holes	l.f.	5.00	6,000	30,000
Concrete, gravity walls	c.y.	40.00	2,000	80,000
Concrete, reinforced walls & slab	c.y.	55.00	4,000	220,000
Concrete, mass	c.y.	25.00	113,000	2,825.000

TABLE U-9
TREXLER PROJECT COST ESTIMATE

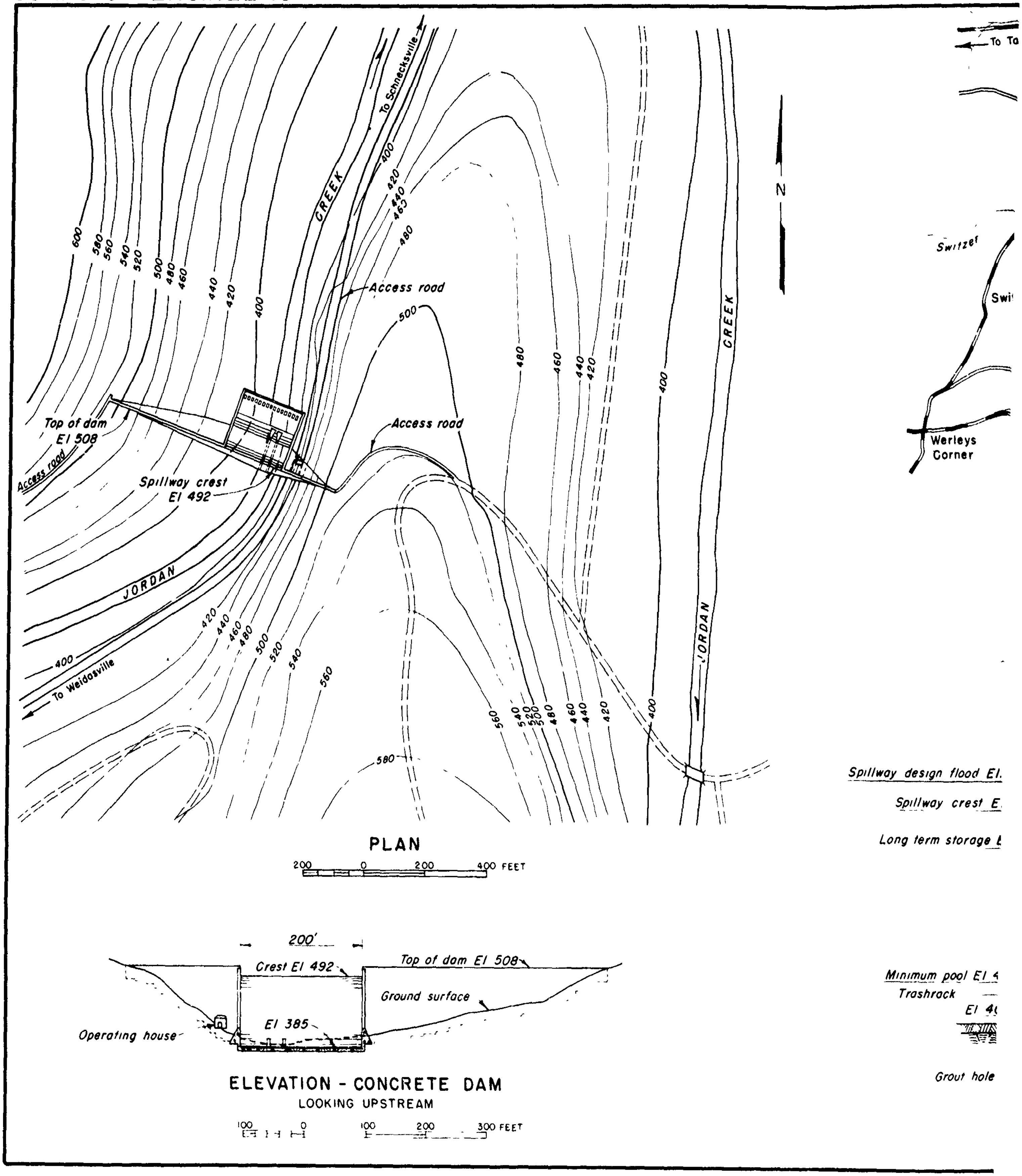
Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works - Continued				
Cement	bbl.	$6.00	122,000	$732,000
Reinforcing steel	lb.	0.20	400,000	80,000
Rubber water stop	l.f.	3.00	4,000	12,000
Miscellaneous steel	lb.	0.60	50,000	30,000
Operating house	job	l.s.	-	7,000
Gates	lb.	0.60	65,000	39,000
Gate operating system	job	l.s.	-	6,000
By-pass system	job	l.s,	-	8,000
Float well & drain system	job	l.s,	-	15,000
Lighting and power system	job	l.s.	-	11,000
Heating and ventilating system	job	l.s.	-	6,000
Trolley hoist 5 ton	job	l.s.	-	9,000
Chain hoist 1-1/2 ton	job	l.s.	-	1,000
Tile gauge	job	l.s.	-	3,000
Contingencies, approx. 20%				941,000
Total - Dam and Appurtenant Works				5,636,000
Engineering and Design				507,000
Supervision and Administration				564,000

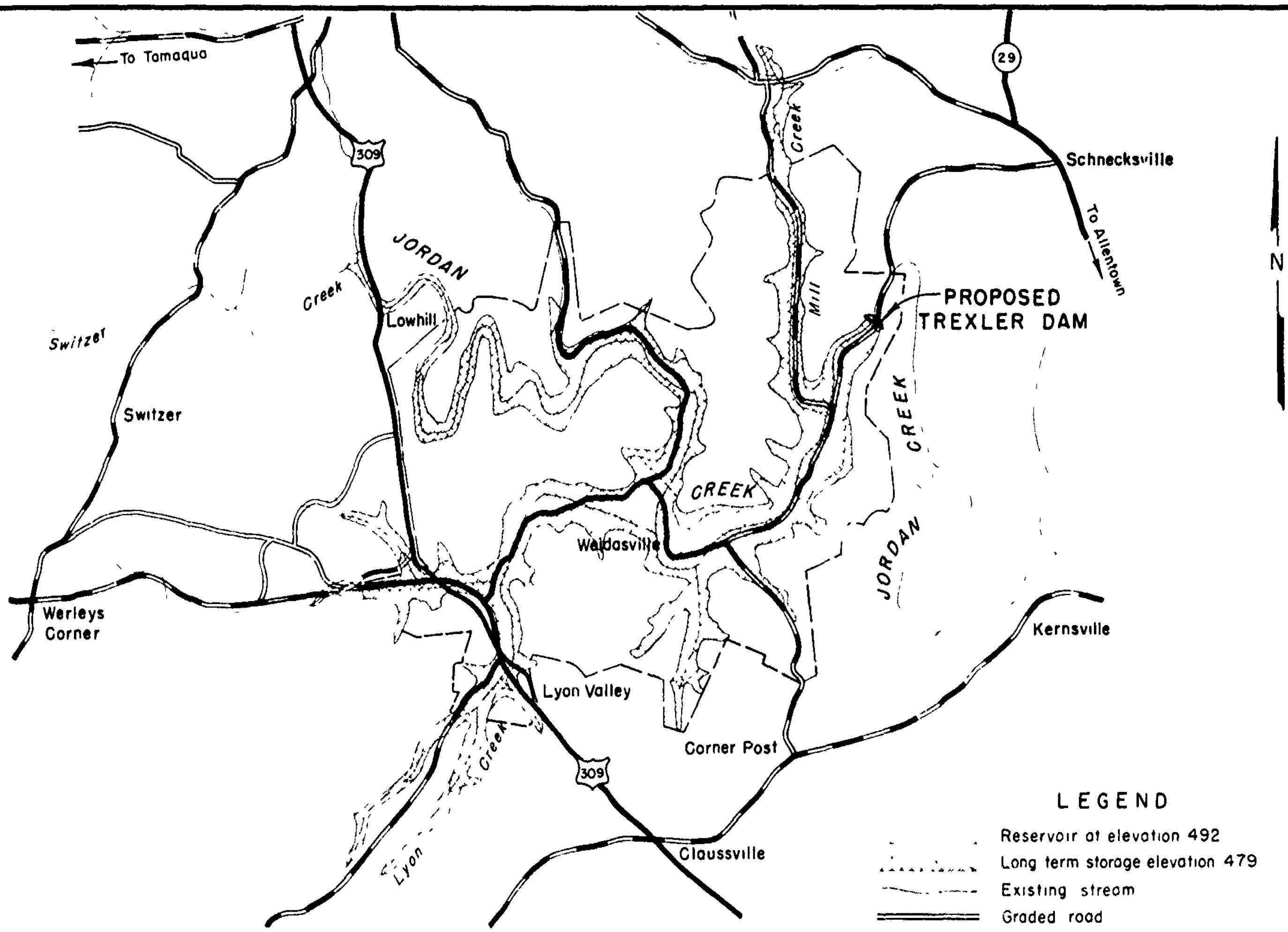
TABLE U-9
TREXLER PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Access Road				
Improve existing road	mi.	$25,000	1.6	$40,000
New Road	mi.	40,000	1/2	20,000
Contingencies, 25%				15,000
Total - Access Road				$75,000
Engineering and Design				7,000
Supervision and Administration				8,000
Recreation				
Facilities 1/	job	l.s.	-	$1,485,000
Real Estate, 2627 acres	job	l.s.	-	1,153,000
Total - Recreation				$2,638,000
Building, grounds, utilities				
Administration, maintenance building, etc.	job	l.s.	-	$25,000
Contingencies, approx. 25%				6,000
Total - Building, Grounds, Utilities				$31,000
Engineering and Design				3,000
Supervision and Administration				3,000

1/ Includes contingencies, engineering, design, supervision and administration

CORPS OF ENGINEERS



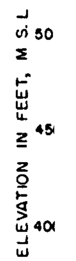


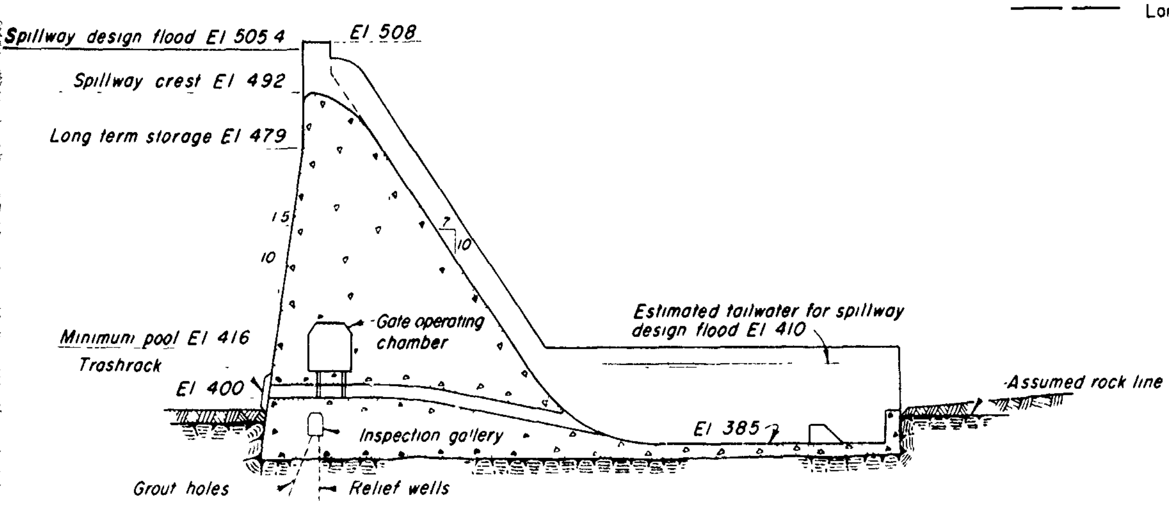
LEGEND

Reservoir at elevation 492
Long term storage elevation 479
Existing stream
Graded road
Hard surface heavy duty road
Secondary hard surface road
Secondary hard surface road, relocated
Hard surface heavy duty road, relocated
Land acquisition for recreation development

RESERVOIR MAP

1 1/2 0 1 MILE





SECTION - CONCRETE DAM

30 0 30 60 FEET

REVIEW

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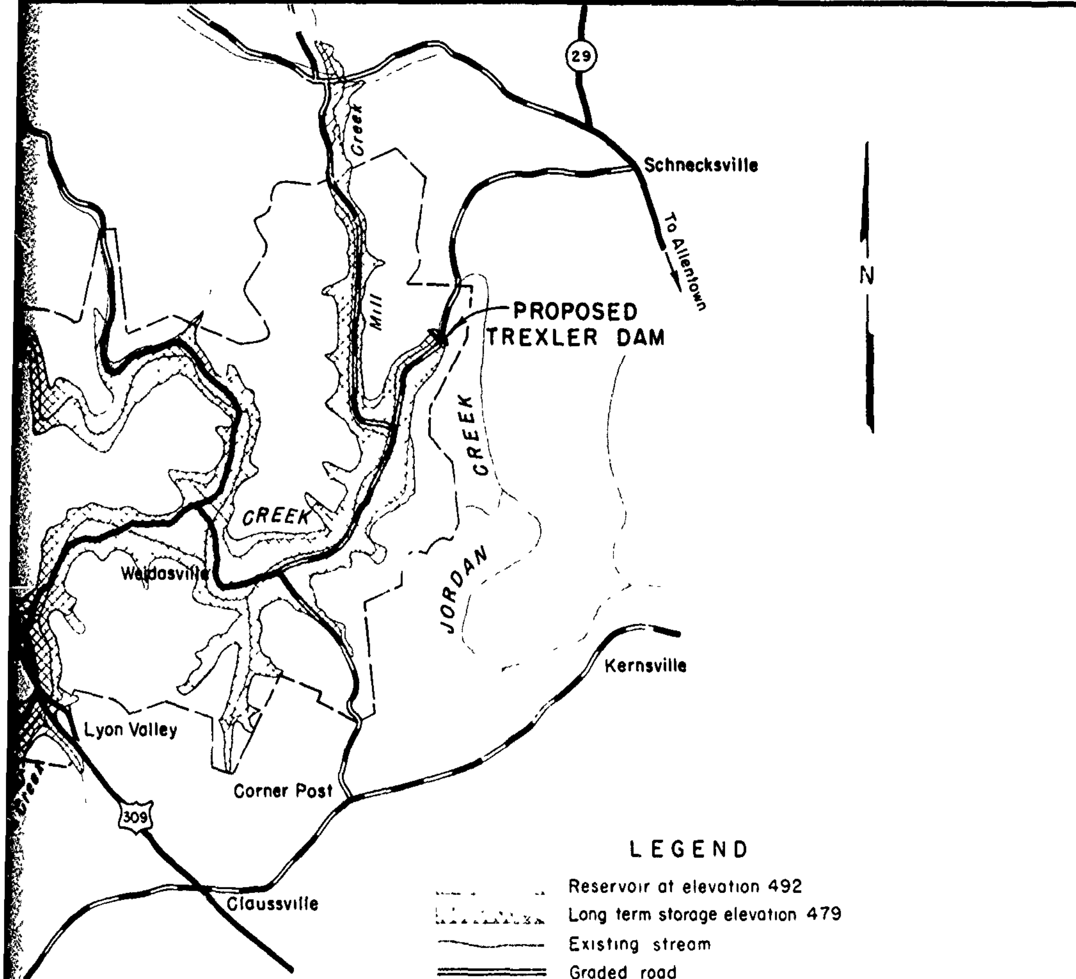
In 1 sheet
Corps of Engin

Drawer No 22

U. S. ARMY

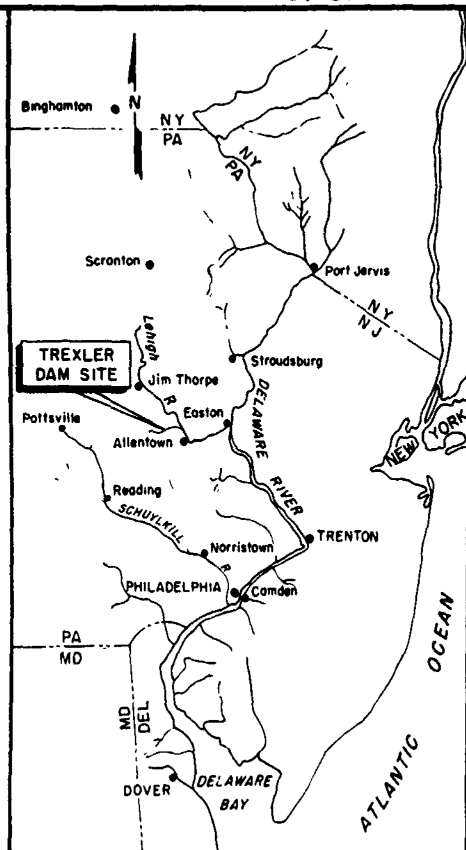


LEGEND

- Reservoir at elevation 492
- Long term storage elevation 479
- Existing stream
- Graded road
- Hard surface heavy duty road
- Secondary hard surface road
- Secondary hard surface road, relocated
- Hard surface heavy duty road, relocated
- Land acquisition for recreation development

SERVOIR MAP

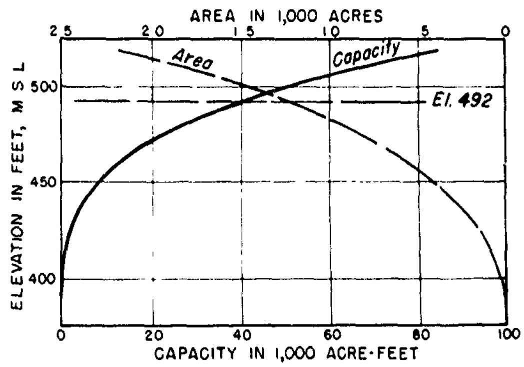
0 1 MILE



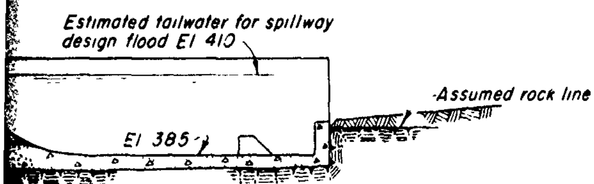
LOCATION MAP

SCALE

10 0 10 20 30 40 MI



AREA AND CAPACITY CURVES



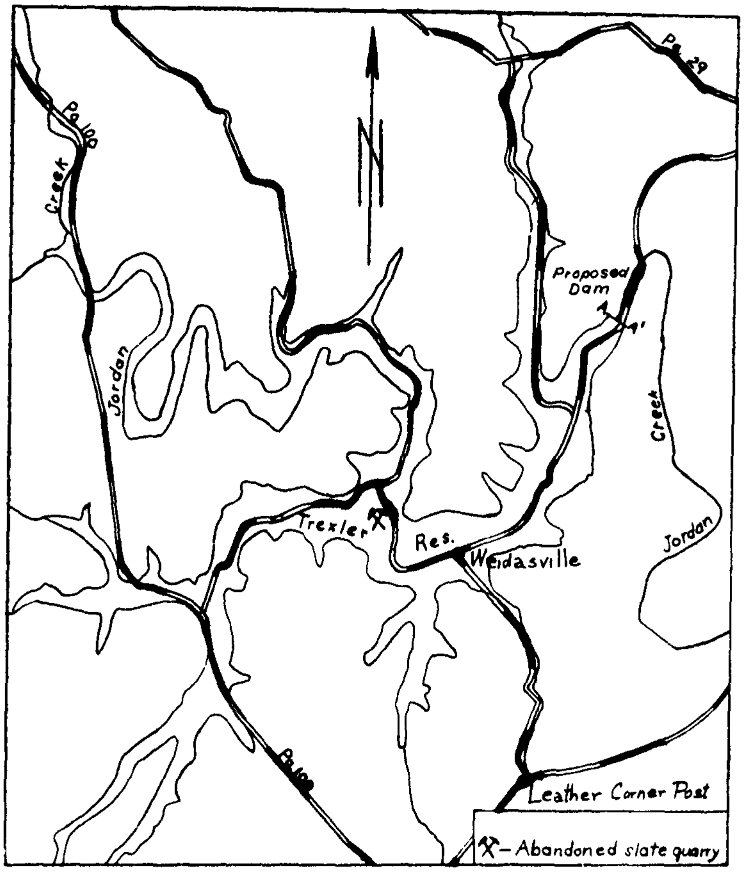
NCRETE DAM

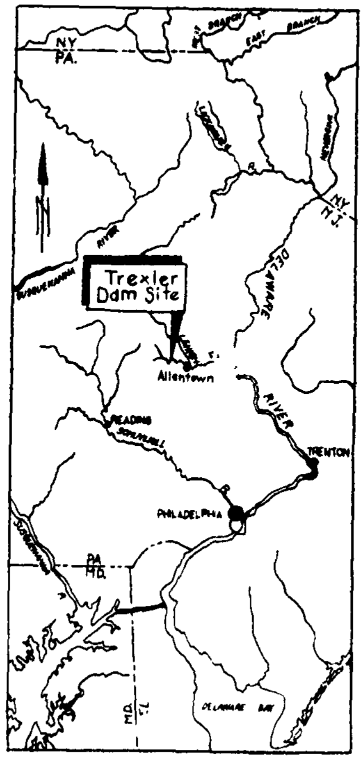
30 60 FEET

REVIEW REPORT DELAWARE RIVER BASIN

TREXLER PROJECT

In 1 sheet	Scale as shown
Corps of Engineers	Philadelphia District
Drawer No 228	File No 29097

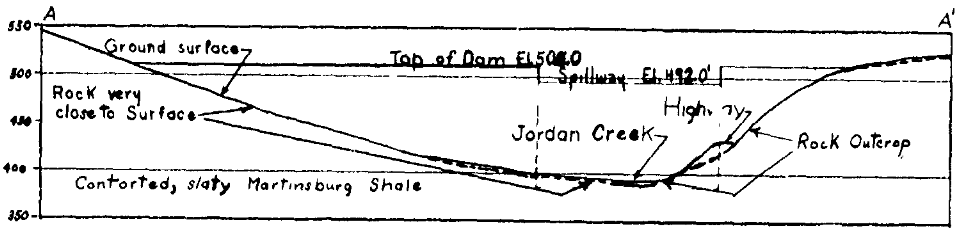




LOCATION MAP

RESERVOIR MAP

0 ½ 1 2 miles



PROFILE ALONG LINE A-A'

0 50 100 200 300 400 500 FT

NOTES:

1. Entire reservoir area underlain by Martinsburg Shale.
2. No borings made because of outcrop and very thin overburden.

REVIEW REPORT DELAWARE RIVER BASIN

TREXLER PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
5 Jan 60

Drawer No 228

File No 29082

31. Christiana Project

a. Christiana Dam would be located across the valley of Christina River about 1-1/2 miles southwest of Christiana, Delaware and 10 miles southwest of Wilmington, Delaware. The drainage area above this site is 41 square miles. Data on basic dimensions of the project are as follows:

Capacity
Long term, 37,000 ac.-ft. stream bed to elevation 49

Elevations
Top of dam, 62
Spillway crest, 49
Outlet, upstream invert, 3
Stream bed at dam, 3

Area
Reservoir at elevation 49, 2,900 acres

b. This site is located in the lower region of the Basin where bedrock occurs at great depth. The valley is broad and shallow and is cut through Pleistocene deposits and into the underlying Cretaceous beds. As indicated by 4 drill holes, the material under the dam and spillway would be silty clay, sandy clay and clayey sand with lenses of fine sand and coarse gravelly sand. This material is estimated to range from relatively impermeable to moderately permeable. Logs and locations of the drill holes are shown on plate 24.

c. The dam proposed for this site would be earth fill approximately 3,800 feet long by 59 feet high. Earth material for the embankment would come from borrow areas upstream within a mile of the dam along construction roads. Riprap would come from rock outcrops along route 896 near the upper end of the reservoir along Christina River. The spillway would be a concrete lined chute through the hill which constitutes the left (west) abutment of the dam. This spillway would have a broad crest at elevation 49, about 46 feet above riverbed. Diversion flows would be carried through an 8'x10' concrete conduit built on natural ground at the base of the left abutment. After the requirement for diversion has been fulfilled two 36 inch diameter concrete pipes would be installed in the conduit to carry reservoir releases.

d. The reservoir to be formed by this dam, up to elevation 49, would extend about 6.7 miles up the river and about 3.8 miles up Muddy run, submerging existing Silver Lake. No main roads cross the reservoir but it would make necessary the raising of two bridges on U. S. Route 40, one mile of the Pennsylvania Railroad single track line from Porter to Newark, Delaware, two new bridges on State Route

PRECEDING PAGE NOT FILMED

896 and other relocations. A proposed four-lane divided highway which would cross two "arms" of the reservoir west and southwest of Salem Church if constructed as proposed, would have to be raised; and since this road has not yet been built, the cost estimates do not include any cost for raising it. There are no communities in the reservoir area and the only commercially valuable mineral deposit is one gravel pit about 1/2 mile upstream from the dam site.

TABLE U-10

CHRISTIANA PROJECT COST ESTIMATE

Description	Estimated Cost
Lands & Damages	$2,700,000
Relocations	2,419,000
Reservoir Clearing	582,000
Dam & Appurtenant Works	3,489,000
Fish & Wildlife, mitigation of losses 1/	-
Access Road	16,000
Recreation, 2/	12,985,000
Building, Grounds, Utilities	31,000
Engineering and Design	588,000
Supervision and Administration	654,000
TOTAL PROJECT COST	$23,464,000

1/ Appendix J contains means of mitigating losses to game habitat and public hunting expected to be caused by the project. These means include the development of habitat improvement and public hunting opportunity on 1000 acres of land and 10 one-half acre pot-holes on State land in New Castle County, Delaware. The cost required to provide these mitigations is a project cost, and while omitted from the estimate above is taken into account in the economic analyses in Appendix V.
2/ This cost includes engineering, supervision, etc.

TABLE U-10

CHRISTIANA PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and Severance, 3050 ac.	job	l.s.	-	$ 1,008,000
Improvements, 84 units	"	"	-	1,146,000
Resettlement, 84 units	"	"	-	46,000
Easement, 300 ac.	"	"	-	84,000
Contingencies, approx. 15%				346,000
Acquisition	ownership	$700	100	70,000
Total - Lands and Damages				2,700,000
Relocations				
Highways				
Improve U.S. Route No. 40	mile	283,000	0.6	170,000
New Bridges (2) for U.S. Route No. 40	job	l.s.	-	224,000
Improve Delaware Route No. 896	mile	238,000	0.5	119,000
New Bridges (2) for Delaware Route No. 896	job	l.s.	-	112,000
Relocate Secondary Hard Surface Roads	mile	120,000	1.9	228,000
New Bridges (3) for Secondary Hard Surface Roads	job	l.s	-	280,000
Relocated graded rd.	mile	80,000	0.8	64,000
New Bridge for graded rd.	job	l.s.	-	58,000
Contingencies, approx. 25%				314,000
Subtotal, Highways				1,569,000

TABLE U-10

CHRISTIANA PROJECT COST ESTIMATES

Description	Unit	Unit Price	Quantity	Cost
Relocations, cont'd				
Railroads				
Raise Existing Railroad	mile	$ 140,000	1	$ 140,000
New Railroad Bridges (3)	job	l.s	-	210,000
Contingencies, Approx. 25%				88,000
Subtotal, Railroads				438,000
Utilities and Cemeteries				
Relocate Steel Tower Power Line	mile	37,000	5.8	215,000
Relocate Service Pole Lines	mile	5,000	3	15,000
Cemetery	grave	200	500	100,000
Contingencies, Approx. 25%				82,000
Subtotal, Utilities and Cemeteries				412,000
Total, Relocations				2,419,000
Engineering and Design				218,000
Supervision and Administration				242,000
Reservoir Clearing				
Agricultural Land	acre	80	900	72,000
Woodland Medium Clearing	acre	210	1,740	365,000
Residential	acre	50	100	5,000
Recreational	acre	50	200	10,000
Commercial	acre	50	10	1,000
Gravel Pit	acre	0	100	0
Farm Units	each	500	12	6,000
Dwellings	each	75	66	5,000

TABLE U-10

CHRISTIANA PROJECT COST ESTIMATES

Description	Unit	Unit Price	Quantity	Cost
Churches, Commercial Units, etc.	each	$ 300	6	$ 2,000
Contingencies, Approx. 25%				116,000
Total - Reservoir Clearing				582,000
Engineering and Design				52,000
Supervision and Administration				58,000
Dam and Appurtenant Works				
Embankment				
Clearing and Grubbing	acre	600	40	24,000
Diversion and Care of River	job	l.s.	1	50,000
Stripping	c.y.	0.80	30,000	24,000
Excavation Cut Off Trench	c.y.	1.00	85,000	85,000
Excavation, Borrow, Impervious	c.y.	0.65	360,000	234,000
Compacted Fill, Impervious	c.y.	0.30	320,000	96,000
Compacted Fill, Random	c.y.	0.30	240,000	72,000
Additional Compaction	R.Hr.	15.00	400	6,000
Filter Material	c.y.	4.00	69,000	276,000
Riprap bedding	c.y.	3.00	15,000	45,000
Riprap dumped	c.y.	9.00	30,000	270,000
Seeding	c.y.	0.70	10,000	7,000
Service Road	job	l.s.	1	35,000
Contingencies, Approx. 20%				245,000
Subtotal, Embankment				1,469,000

TABLE U-10

CHRISTIANA PROJECT COST ESTIMATES

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works, Cont'd				
Outlet Works				
Excavation Common	c.y.	1.00	15,000	$ 15,000
Backfill Compacted	c.y.	1.50	4,500	7,000
Concrete Conduit	c.y.	60.00	1,500	90,000
Concrete Headwalls & Stilling Basin	c.y.	60.00	200	12,000
Concrete Plug for Conduit	c.y.	60.00	40	2,000
Precast 36" Concrete Pipe	l.f.	20.00	800	16,000
Cement	bbl.	6.00	2,500	15,000
Reinforcing Steel	lb.	0.20	200,000	40,000
Rubber Water Stops	l.f.	3.00	1,000	3,000
Riprap, dumped	c.y.	9.00	1,400	13,000
Misc. Metal	lb.	0.60	10,000	6,000
Valves, 36" dia.	each	5,000	4	20,000
Reservoir Elevation gauges	job	l.s.	-	2,000
Lighting	job	l.s.	-	5,000
By-pass System	job	l.s.	-	6,000
Contingencies, approx. 20%				51,000
Subtotal, Outlet Works				303,000

TABLE U-10

CHRISTIANA PROJECT COST ESTIMATES

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works, Cont'd				
Spillway				
Excavation Common	c.y.	0.60	500,000	$ 300,000
Backfill Compacted	c.y.	1.50	26,000	39,000
Gravel Filter Material	c.y.	4.00	8,000	32,000
Riprap, dumped	c.y.	9.00	1,300	12,000
Vitrified Clay Pipe 6"	l.f.	1.00	3,000	3,000
Concrete Walls	c.y.	30.00	16,700	501,000
Cement	bbl.	6.00	21,000	126,000
Reinforcing Steel	lbs.	0.20	1,670,000	334,000
Topsoil and Seeding	c.y.	0.70	5,000	4,000
Steel Sheet Piling	lb.	0.20	400,000	80,000
Contingencies, approx. 20%				286,000
Subtotal, Spillway				1,717,000
Total - Dam and Appurtenant Works				3,489,000
Engineering and Design				314,000
Supervision and Administration				349,000
Access Road				
Access Road	job	l.s.		13,000
Contingencies, Approx. 25%				3,000
Total - Access Road				16,000
Engineering and Design				1,000
Supervision and Administration				2,000

TABLE U-10

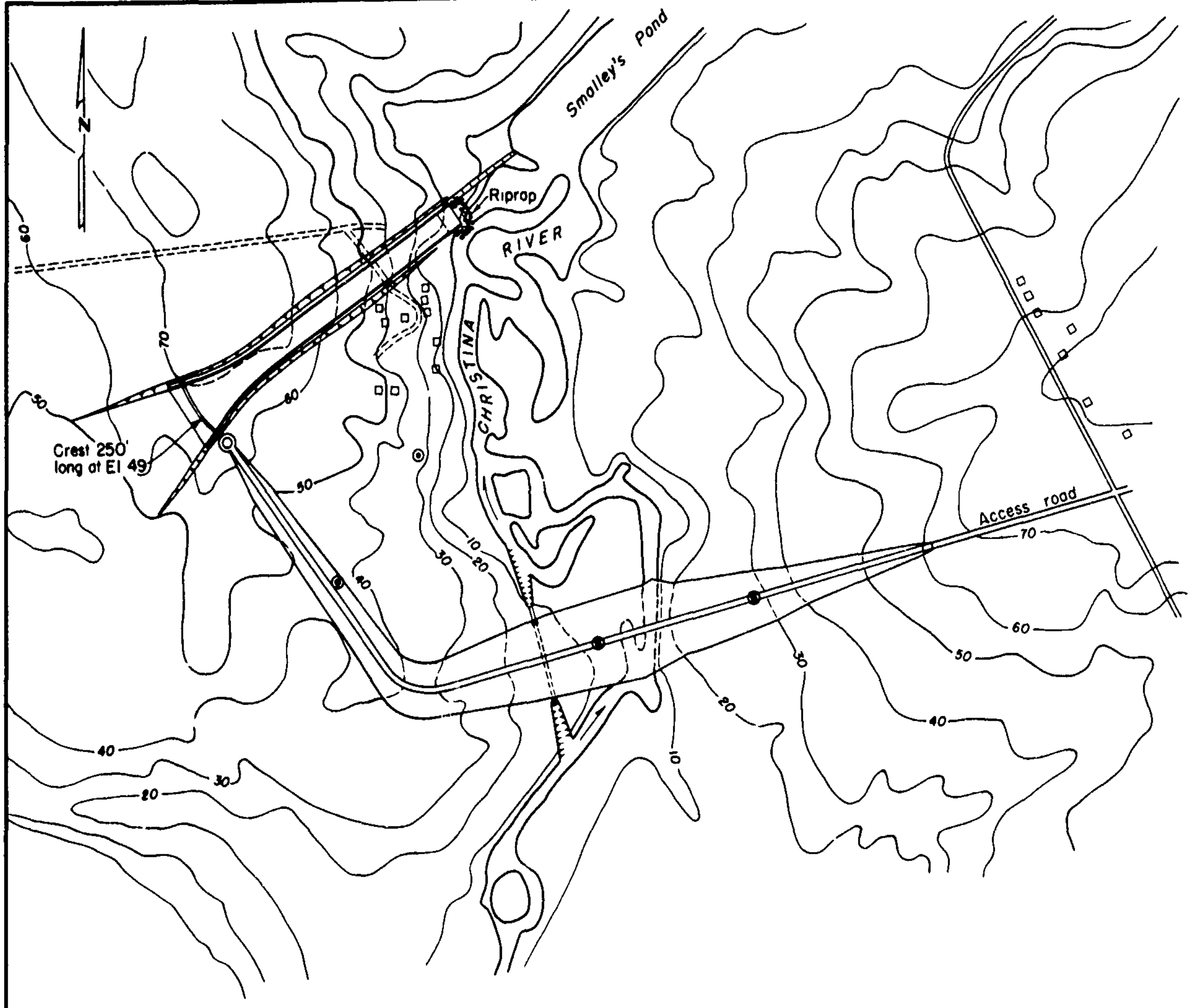
CHRISTIANA PROJECT COST ESTIMATES

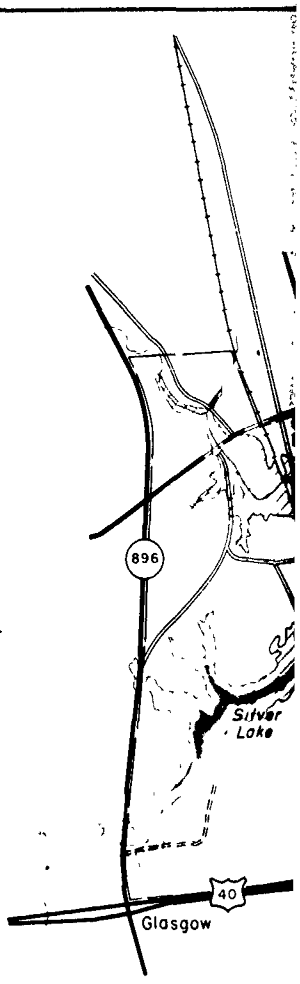
Description	Unit	Unit Price	Quantity	Cost
Recreation				
Facilities 1/	job	l.s.	-	$ 6,395,000
Real Estate, 5,030 ac.	job	l.s.	-	6,590,000
				12,985,000

1/ Includes contingencies, engineering, design, supervision and administration.

Buildings, Grounds, Utilities				
Administration, Maintenance Building, etc.	job	l.s.		25,000
Contingencies, Approx. 25%				6,000
Total - Building, Grounds, Utilities				31,000
Engineering and Design				3,000
Supervision and Administration				3,000

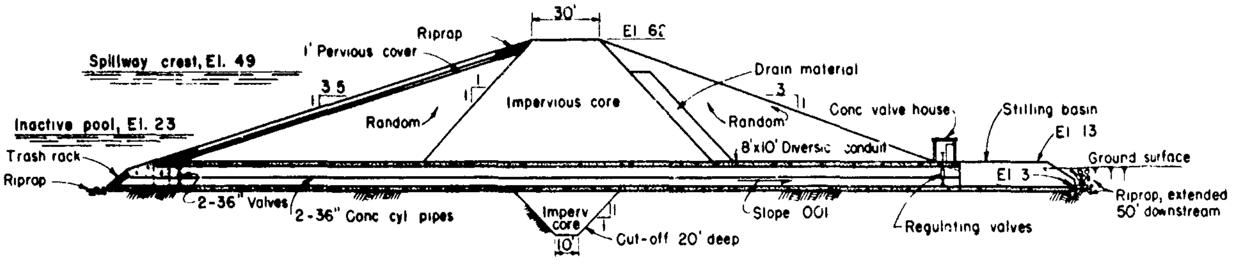
CORPS OF ENGINEERS

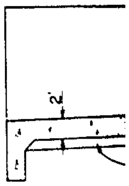




PLAN

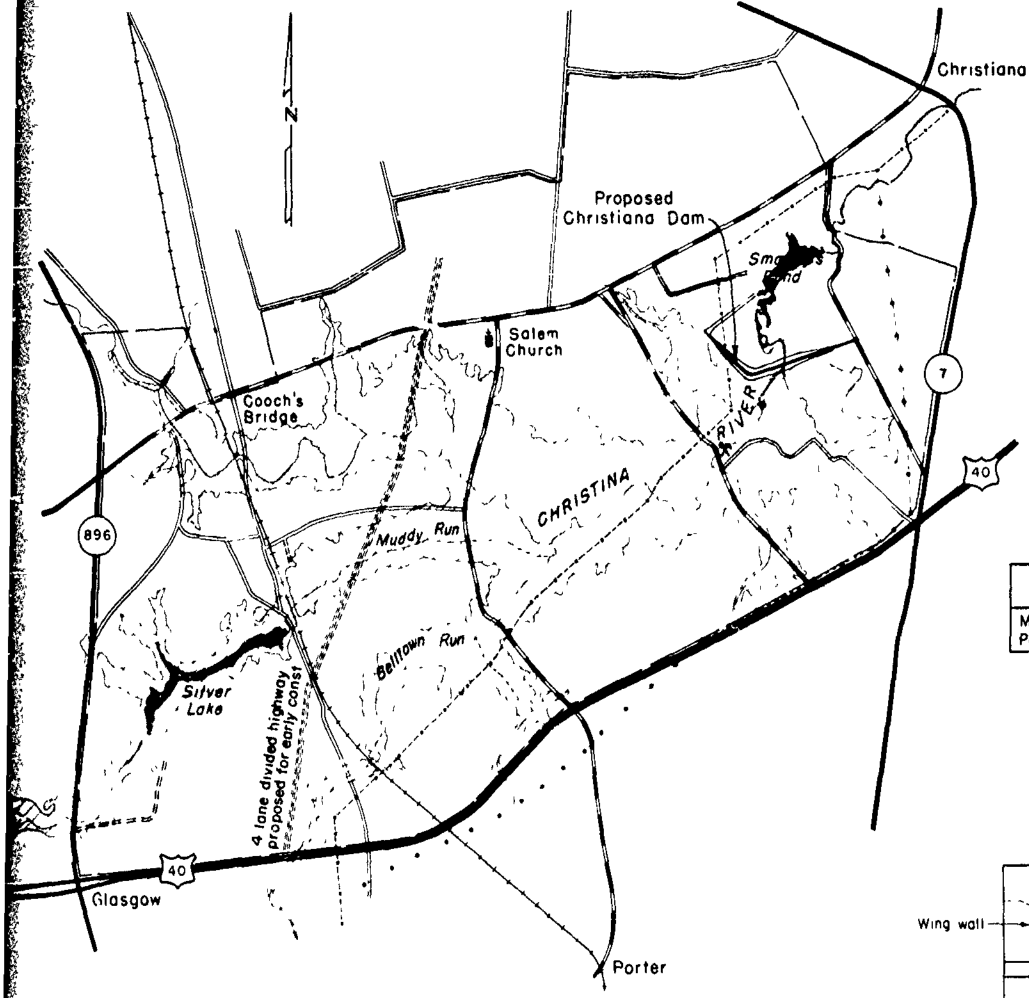
400 0 400 800 FEET





SECTION - OUTLET WORKS

20 0 20 40 60 80 FEET



RESERVOIR MAP

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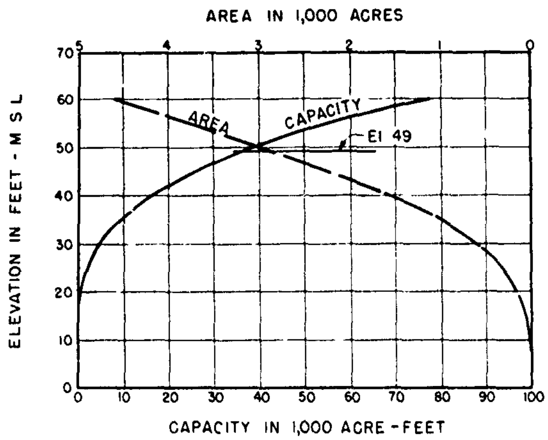

RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	49	37,000	2,900

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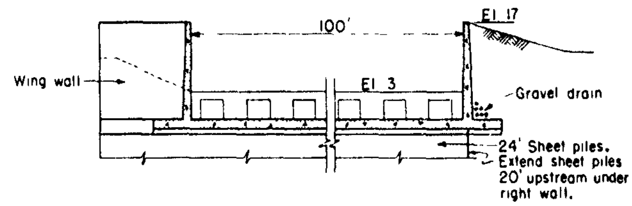
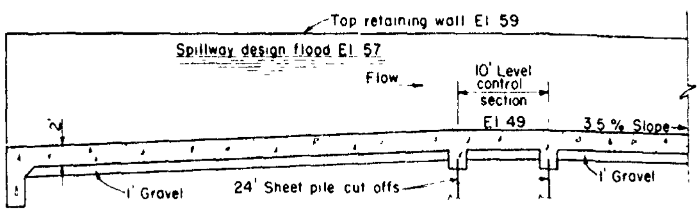


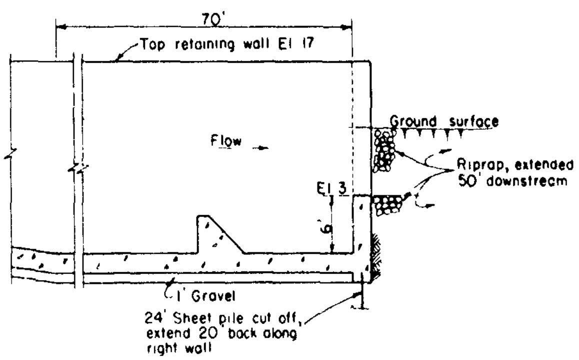
SECTION THRU STILLING BASIN
(LOOKING DOWNSTREAM)

20 0 20 40 FEET



SECTION - SPILLWAY CREST

10 0 10 20 FEET



SECTION - STILLING BASIN

10 0 10 20 FEET

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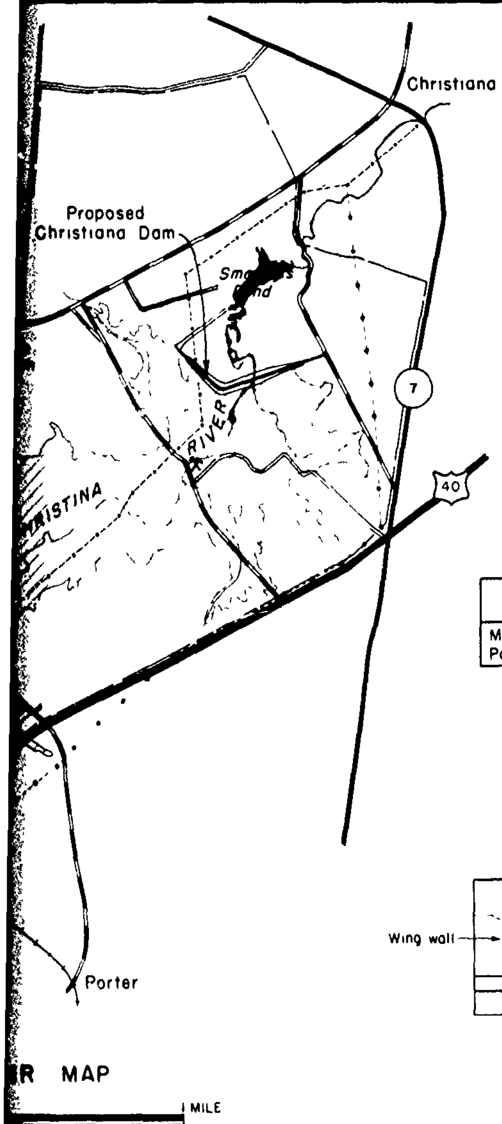
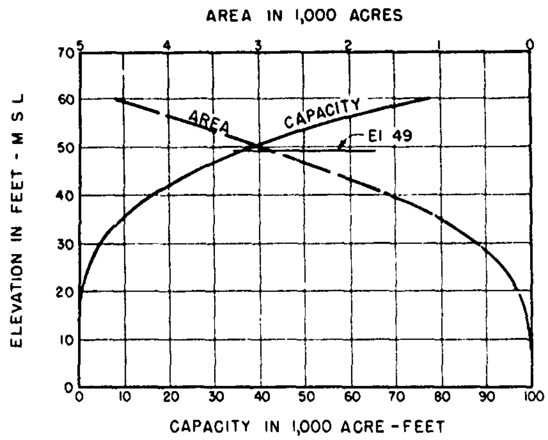
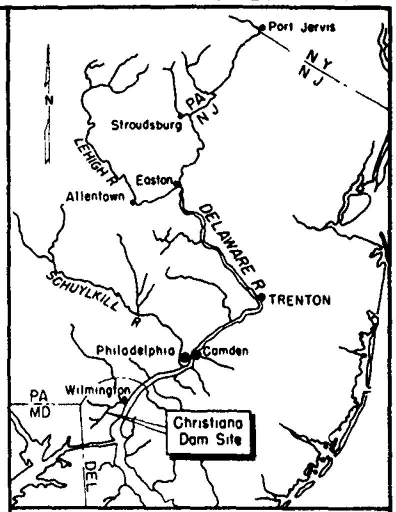




RESERVOIR AREA AND CAPACITY CURVES



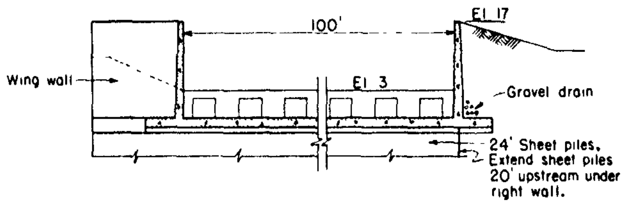
LOCATION MAP

SCALE

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple - Purpose Pool	49	37,000	2,900

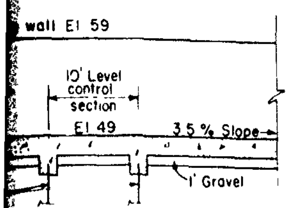
LEGEND

- Multiple - Purpose Pool El 49
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Proposed Relocated Graded Road
- Proposed Raised Hard Surface Heavy Duty Road
- Proposed Raised Secondary Hard Surface Road
- Proposed Raised Railroad
- Proposed Relocated Power Line
- Land Acquisition for Recreation Development
- Drill Hole
- Gravel Pit



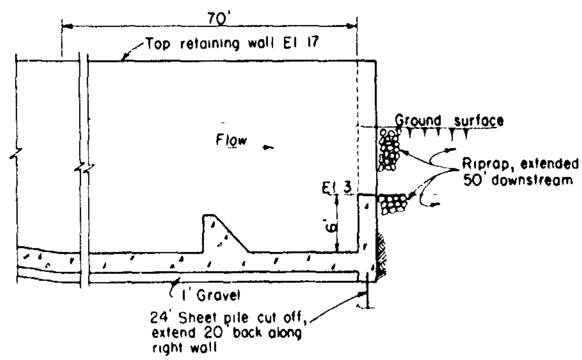
SECTION THRU STILLING BASIN
(LOOKING DOWNSTREAM)

20 0 20 40 FEET



AY CREST

20 FEET



SECTION - STILLING BASIN

10 0 10 20 FEET

REVIEW REPORT DELAWARE RIVER BASIN

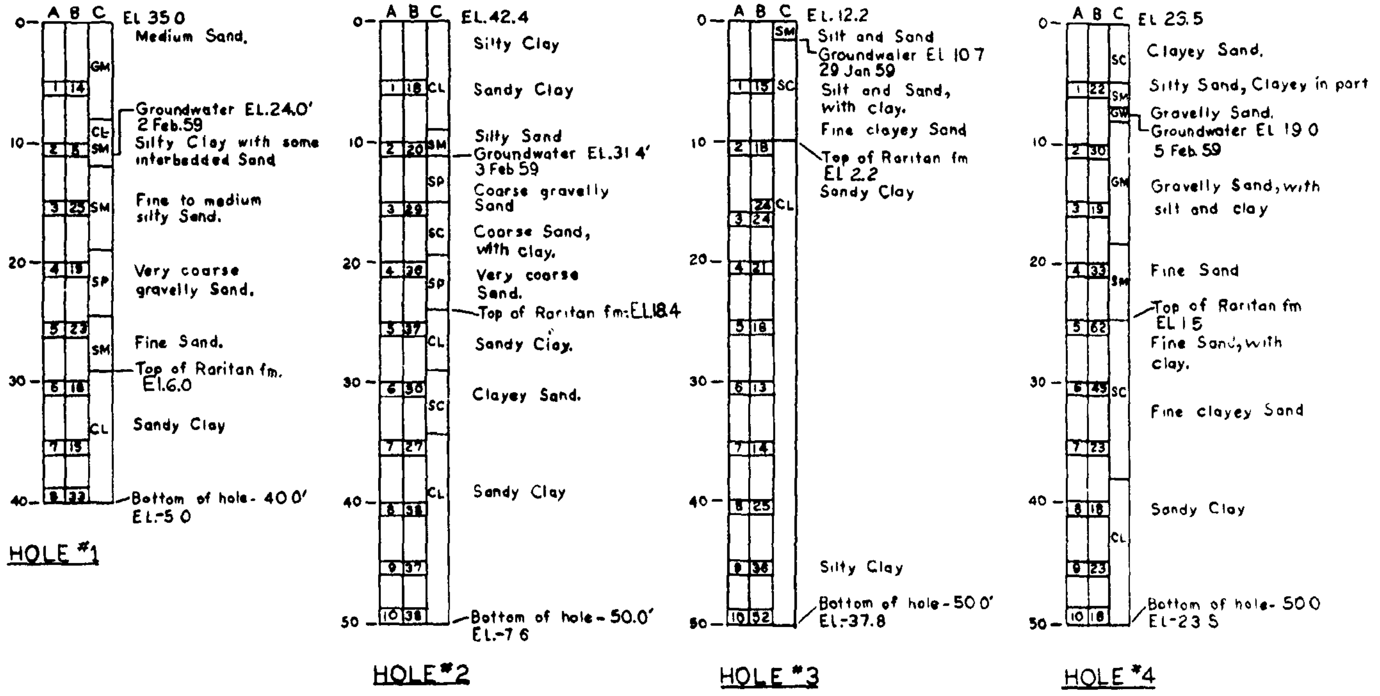
CHRISTIANA PROJECT

In 1 Sheet — Scales as Shown

Corps of Engineers, Philadelphia, Pa — Philadelphia District, June 1960

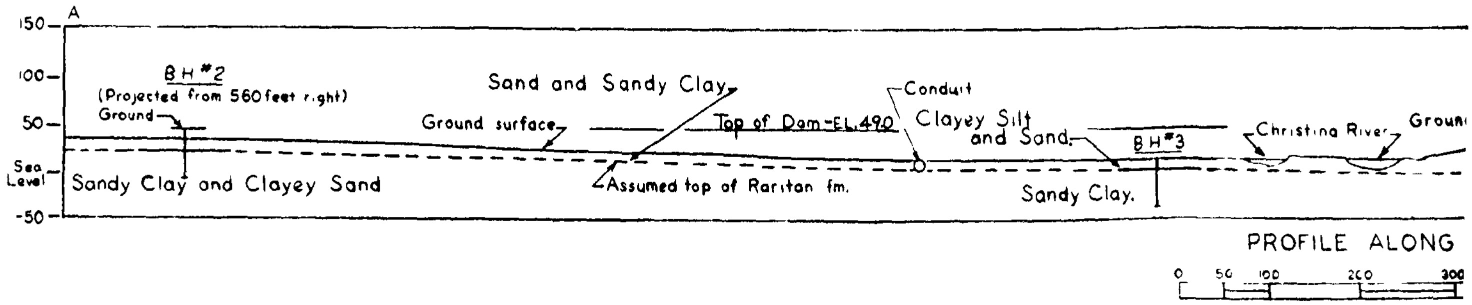
Drawer No 228 — File No 29121

CORPS OF ENGINEERS



NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of spoon samples.
2. Column "A" refers to the sample number
3. Column "B" refers to the number of blows a 140 lb. hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered
4. Column "C" is a field classification of the materials encountered, using the Unified Soils Classification System symbols.
5. All elevations based on mean sea level datum
6. Work performed by Corps of Engineers, Phila Dist Office during Jan, Feb. 1959.
7. The material above Raritan fm. consists of Pleistocene or Recent terrace and other alluvial deposits.



Sand
Sand, Clayey in part
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d clay

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Clayey Sand

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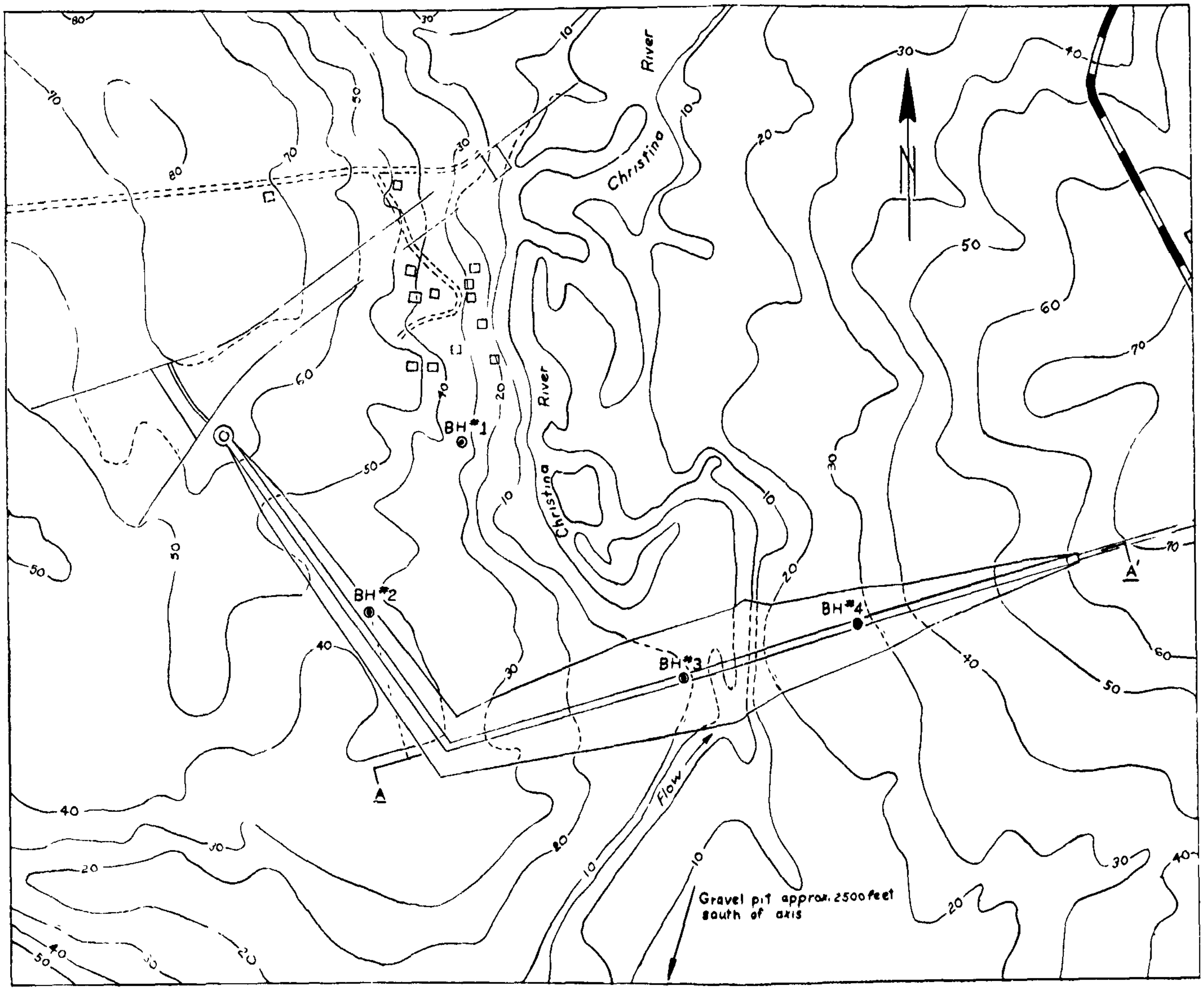
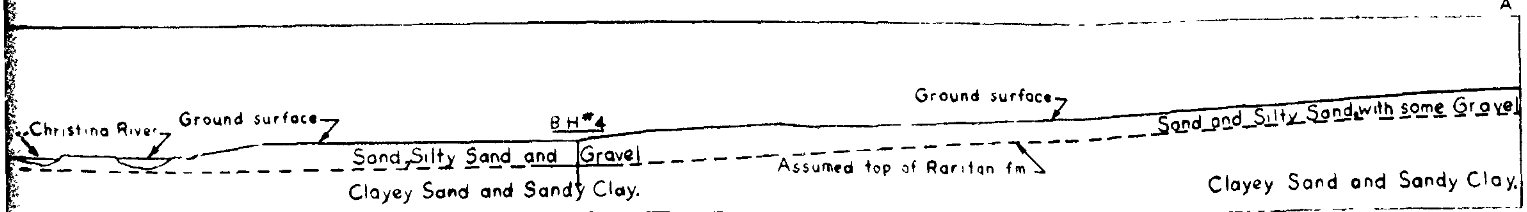


SITE MAP

0 100 200 500 1000 1500 FT



PROFILE ALONG LINE A-A'

100 200 300 400 500 FT

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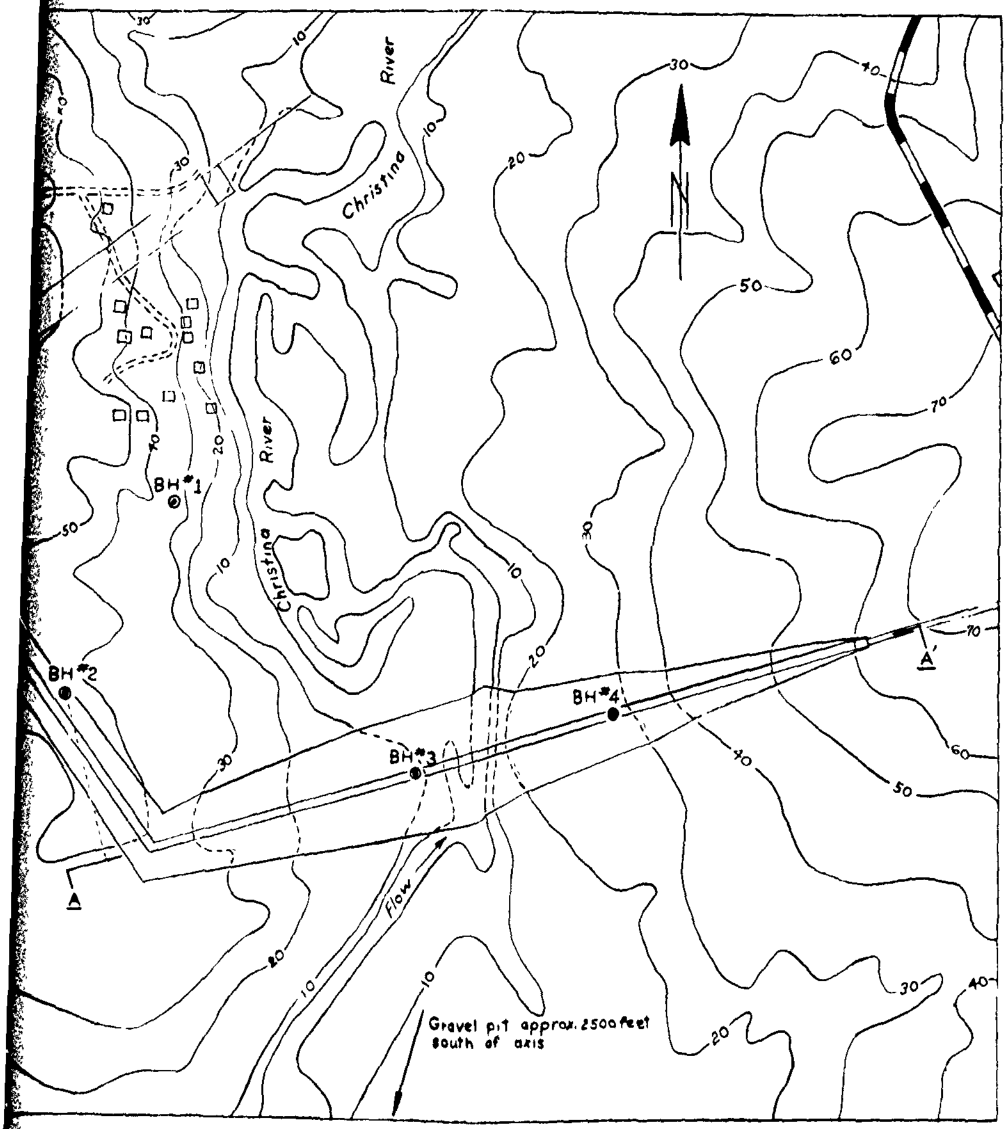
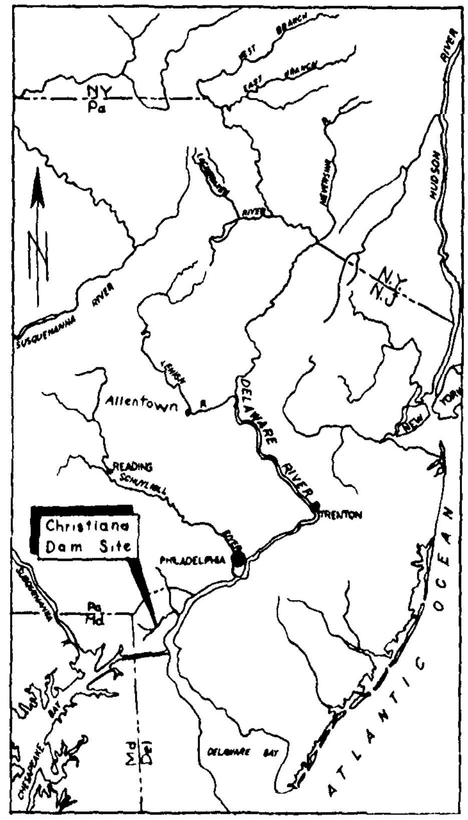
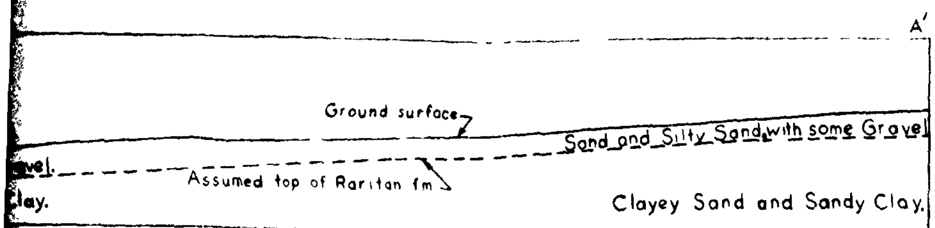


SITE MAP



LOCATION MAP



REVIEW REPORT DELAWARE RIVER BASIN

CHRISTIANA PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
28 Jan. 60

Drawer No 228

File No. 29086

32. Hawk Mountain Project

a. Hawk Mountain dam, as proposed, would be located across the East Branch of the Delaware River about 2-1/2 miles east of Hancock, New York. The drainage area above this site is 812 square miles. Four hundred forty square miles of this drainage area are downstream from Pepacton reservoir which was built by the New York Board of Water Supply about two miles upstream from the upper end of the proposed Hawk Mountain reservoir. Data on basic dimensions of the project are as follows:

Capacity
Long term, 293,000 ac.-ft., stream bed to elevation 1,082

Elevations
Top of dam, 1,109
Spillway crest, 1,082
Outlet, upstream invert, 932
Stream bed at dam, 932

Area
Reservoir at elevation 1,082, 5,400 acres

Power
Installed capacity, 21,000 kilowatts

b. The river, at the selected site, has incised a deep buried valley into the flat-lying red and gray sandstone, siltstone and infrequent shale beds of the middle and upper Devonian Catskill series. These beds, deposited as delta deposits, were slightly folded during the Appalachian Revolution, but were later uplifted and eroded. Present forms are due to this erosion, modified by Pleistocene glaciation which deposited great quantities of relatively impermeable glacial drift in the valley. Subsurface conditions were examined by three test holes shown on plate 26.

c. The proposed earth and rockfill dam would rise to 177 feet above the riverbed with a top length of 1,900 feet. Material for the dam would come from spillway excavation and from borrow areas upstream from the dam along highway number 17. A side-channel spillway with a 550-foot long crest at elevation 1,082 would be cut into the left (east) abutment to convey water through a chute and stilling basin down to the river channel at a point 1,200 feet downstream from the toe of the dam. Two 18-foot diameter horseshoe shaped concrete conduits would be constructed on rock along the left bank of the river with gates and a control tower at the upstream end. After serving as diversion conduits during construction, a 13-foot diameter steel penstock would be installed in each conduit from the center of the dam to the powerplant. All reservoir releases would be made through the

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powerplant or through 4'x3' bypasses to be constructed in the powerplant substructure. The powerplant would contain two generators of 10,500-kilowatt capacity each, with turbines and the necessary auxiliary equipment. A switchyard would provide equipment for transforming the generated current to 110 kilovolts.

d. The reservoir, up to elevation 1,082, would extend upstream about 22 miles to a point about one mile downstream from Downsville, New York. This reservoir would make it necessary to relocate 21-1/2 miles of state highways 17 and 30 and the communities of Fishs Eddy and East Branch. At the present time (1960) an extensive construction program is underway that, when completed, will make Route 17 four lanes wide throughout most of the reservoir area. The railroad which formerly ran in this valley is not now operating. The only commercially developed mineral deposit in vicinity of the reservoir area is a quarry producing crushed sandstone about 1/2 mile upstream from the dam site. The source of sandstone is above reservoir level, but crushing operations are below it. Other gravel pits or quarries in the reservoir area, which were operated in the past, have either been abandoned or are operated only intermittently.

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

1/ Description	Estimated Cost
Lands and Damages	$ 3,615,000
Relocations	11,158,000
Reservoir	1,276,000
Dam and Appurtenant Works	14,330,000
Fish and Wildlife, Mitigation of losses 1/	-
Power Plant	4,268,000
Recreation 2/	1,415,000
Building, Grounds, Utilities	31,000
Engineering and Design	2,796,000
Supervision and Administration	3,107,000
TOTAL PROJECT COST	41,996,000

1/ Appendix J contains means of mitigating losses to stream fisheries, game habitat, and public hunting expected to be caused by the project. These means include the acquisition of public fishing rights and development of 4.5 miles of existing trout stream in Delaware County, New York and the provision of public hunting and habitat improvement on 5600 ac. in that County. The cost required to provide these mitigations is a project cost, and while omitted from the estimate above is taken into account in the economic analyses in Appendix V.

2/ This cost includes engineering, design, supervision and administration.

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and Severance	Job	L.S.	-	$ 495,000
Improvements	Job	L.S.	-	2,230,000
Resettlement	Job	L.S.	-	159,000
Easement	Job	L.S.	-	35,000
Contingencies, approx. 15%				436,000
Acquisition				260,000
Total, Lands and Damages				3,615,000
Relocations				
Highways				
New primary hard surface roads	mile	310,000.00	21.5	6,665,000
New bridges (5) for primary hard surface road	Job	L.S.	-	2,083,000
Contingencies, approx. 25%				2,187,000
Subtotal, Highways				10,935,000
Utilities				
Relocate service pole lines	mile	5,000.00	21.5	108,000
Contingencies, approx. 25%				27,000
Subtotal, Utilities				135,000
Cemeteries				
Relocate cemeteries (4)	grave	200.00	350	70,000
Contingencies, approx. 25%				18,000
Subtotal, Cemeteries				88,000
Total, Relocations				11,158,000
Engineering and Design				1,004,000
Supervision and Administration				1,116,000

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing				
Agricultural Land	acre	80	1,500	$ 120,000
Recreational Land	acre	50	200	10,000
Residential, commercial and cemetery sites	acre	50	400	20,000
Woodland, light clearing	acre	80	700	56,000
Woodland, medium clearing	acre	210	2,000	420,000
Woodland, heavy clearing	acre	350	1,000	350,000
Residences	each	100	213	21,000
Cottages	each	50	60	3,000
Commercial Buildings	each	400	25	10,000
Churches	each	500	4	2,000
Schools	each	500	3	2,000
Farm Units	each	500	13	7,000
Contingencies, approx. 25%				255,000
Total, Reservoir Clearing				1,276,000
Engineering and Design				115,000
Supervision and Administration				128,000
Dam and Appurtenant Works				
Embankment				
Clearing and grubbing	acre	600	33	20,000
Diversion and care of stream	Job	L.S.	1	873,000
Stripping for dam	C.Y.	0.80	109,000	87,000
Excavation, cut-off trench	C.Y.	0.90	110,000	99,000
Excavation, impervious borrow	C.Y.	0.55	1,420,000	781,000
Excavation, random borrow	C.Y.	0.55	910,000	501,000
Excavation, bedding material	C.Y.	0.55	108,000	59,000
Fill, compacted impervious	C.Y.	0.30	1,295,000	389,000
Fill, compacted random	C.Y.	0.30	826,000	248,000
Bedding material	C.Y.	0.30	98,000	29,000
Additional compaction	r.h.	15.00	1,200	18,000
Rock fill	C.Y.	0.35	880,000	308,000
Filter material (processed)	C.Y.	4.00	130,000	520,000
Riprap, dumped	C.Y.	2.00	45,000	90,000
Derrick stone	C.Y.	5.00	11,000	55,000
Contingencies, approx. 20%				813,000
Subtotal, Embankment				4,890,000
Service road on top of dam				
Base course and asphaltic surfacing, 1,850 l.f.	Job	L.S.		22,000
Guard rail	L.F.	3.00	3,700	11,000
Contingencies, approx. 20%				7,000
Subtotal, Service Road				40,000

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works Continued				
Intake Structure and Conduits				
Excav., com. (conduits)	C.Y.	0.55	179,000	$ 98,000
Excav., com. (intake chan.)	C.Y.	0.55	4,600	3,000
Excav., rock (conduits)	C.Y.	2.00	30,600	61,000
Excav., rock (intake chan.)	C.Y.	2.00	2,200	4,000
Close line drilling	S.F.	4.00	13,300	53,000
Backfill, diversion conduits	C.Y.	1.50	120,000	180,000
Conc. diversion conduits	C.Y.	65.00	17,900	1,164,000
Conc., intake substructure	C.Y.	67.00	2,100	141,000
Conc., intake tower	C.Y.	110.00	1,700	187,000
Cement	bbl.	6.00	32,500	195,000
Reinforcing steel	lb.	0.20	2,142,000	428,000
Rubber water stops	L.F.	3.00	3,000	9,000
Service bridge (400 ft.)	Job	L.S.	-	202,000
Gate hoist, 1@ 30 T. Cap.	Job	L.S.	-	30,000
Stoney gates	lb.	0.60	240,000	144,000
Trashrack	lb.	0.60	25,000	15,000
Miscellaneous metal	lb.	0.60	66,500	40,000
Operating house superstructure	Job	L.S.	-	25,000
By-pass system	Job	L.S.	-	8,000
Floatwell and drain system	Job	L.S.	-	15,000
Lighting and power system	Job	L.S.	-	11,000
Heating and ventilating system	Job	L.S.	-	6,000
Trolley hoist, 5 ton	Job	L.S.	-	9,000
Chain hoist, 1-1/2 ton	Job	L.S.	-	1,000
Tile gage	Job	L.S.	-	3,000
Contingencies, approx. 20%				606,000
Subtotal, Intake Structure and Conduits				3,638,000

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works, Continued				
Spillway				
Clearing and grubbing	acre	600.00	15	$ 9,000
Excav., common	C.Y.	0.55	620,000	341,000
Excav., rock	C.Y.	2.00	635,000	1,270,000
Close line drilling	S.F.	4.00	160,000	640,000
Drilling & pressure grouting	L.F.	9.00	10,000	90,000
Drilling anchor holes	L.F.	6.00	33,300	200,000
Anchor rods	lb.	1.00	172,000	172,000
Riprap dumped	C.Y.	3.60	5,000	18,000
Cement	bbl.	6.00	66,400	398,000
Conc., mass	C.Y.	25.00	23,600	590,000
Conc., walls	C.Y.	29.00	14,300	415,000
Conc., paving	C.Y.	20.00	11,100	222,000
Conc., stilling basin	C.Y.	30.00	4,010	120,000
Reinforcing steel	lb.	0.20	1,473,000	295,000
Rubber water stops	L.F.	3.00	7,200	22,000
Contingencies, approx. 20%				960,000
Subtotal, Spillway				5,762,000
Summary				
Embankment				4,890,000
Service road on top of dam				40,000
Intake structure and conduits				3,638,000
Spillway				5,762,000
Total - Dam and Appurtenant Works				14,330,000
Engineering and Design				1,290,000
Supervision and Administration				1,433,000

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Power Plant				
Tailrace				
Excav., com.	C.Y.	0.55	24,800	$ 14,000
Excav., rock	C.Y.	2.00	21,000	42,000
Excav., structural	C.Y.	2.00	4,500	9,000
Riprap	C.Y.	4.00	300	1,000
Derrick stone	C.Y.	12.00	400	5,000
Conc., walls	C.Y.	55.00	900	50,000
Cement	bbl.	6.00	1,320	8,000
Steel, reinf.	lb.	0.20	60,000	12,000
Line drilling	S.F.	4.00	5,700	23,000
Contingencies, approx. 20%				30,000
Subtotal, Tailrace				194,000
Penstocks				
Penstocks, 5/8" steel, 2-13'I.D.	lb.	0.50	1,020,000	510,000
Conc., cradles and plugs	C.Y.	45.00	650	29,000
Cement	bbl.	6.00	980	6,000
Reinforcing steel	lb.	0.20	65,000	13,000
Pressure relief valves (2)	Job	L.S.	-	33,000
Contingencies, approx. 20%				119,000
Subtotal, Penstocks				710,000
Substructure				
Excav., com.	C.Y.	0.55	7,850	4,000
Excav., rock	C.Y.	2.00	1,000	2,000
Backfill, compacted	C.Y.	1.50	2,000	3,000
Close line drilling	S.F.	4.00	1,500	6,000
Steel, structural	lb.	0.65	18,000	12,000
Foundation preparation	S.Y.	6.70	100	1,000
Handrail	L.F.	4.00	200	1,000
Conc., mass	C.Y.	27.00	2,250	61,000
Conc., floor finish	S.F.	0.40	2,400	1,000
Cement	bbl.	6.00	3,000	18,000
Miscellaneous metal	lb.	0.60	4,500	3,000
Reinforcing steel	lb.	0.20	45,000	9,000
Gates, 2-4'x3' slide	lb.	0.60	55,000	33,000

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Power Plant, cont'd.				
Substructure, cont'd.				
Rubber water stops	L.F.	3.00	1,000	$ 3,000
Contingencies, approx. 20%				31,000
Subtotal, Substructure				188,000
Superstructure				
Conc., walls	C.Y.	130.00	500	65,000
Cement	bbl.	6.00	750	5,000
Reinforcing steel	lb.	0.20	60,000	12,000
Roof, complete	S.F.	2.10	2,400	5,000
Miscellaneous metal	lb.	0.60	1,000	1,000
Structural steel	lb.	0.40	11,520	5,000
Windows	S.F.	4.25	1,400	6,000
Heat'g., vent'g, plumb'g, & electric systems	Job	L.S.	-	47,000
Contingencies, approx. 20%				28,000
Subtotal, Superstructure				174,000
Service Road				
Portion on dam, surfacing and guardrail, 700 ft.	Job	L.S.	-	7,000
Route 17 to dam; 2400 ft.:				
Clearing, excav., etc.	Job	L.S.	-	9,000
Surfacing	Job	L.S.	-	18,000
Guard rail	L.F.	3.00	2,000	6,000
Contingencies, approx. 20%				8,000
Subtotal, Service Road				48,000
Equipment				
2-15,000 H.P. turbines	H.P.	29.90	30,000	897,000
2-10,500 K.W. generators	KW	49.30	21,000	1,035,000
Appurtenant equipment	KW	2.30	21,000	48,000
Accessory electrical equipment	KW	11.40	21,000	239,000
80 Ton-Cap. crane	Job	L.S.	-	80,000
Contingencies, approx. 20%				460,000
Subtotal, Equipment				2,759,000

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Power Plant, cont'd.				
Switchyard				
Foundations, structures, grading, fencing & grounding	Job	L.S.	-	$ 46,000
Cable, conduit and switches	Job	L.S.	-	32,000
Transformer, 25,000 kva cap.	ea	105,000	1	105,000
Bus wiring, etc.	Job	L.S.	-	7,000
Miscellaneous construction	Job	L.S.	-	5,000
Subtotal, Switchyard				195,000 1/
Power Plant Summary				
Tailrace				194,000
Penstocks				710,000
Substructure				188,000
Superstructure				174,000
Service Road				48,000
Equipment				2,759,000
Switchyard				195,000
Total, Power Plant				4,268,000
Engineering and Design				384,000
Supervision and Administration				427,000

1/ This estimate was made by the Fed. Power Com. The estimated costs of the individual items include contingencies.

TABLE U-11
HAWK MOUNTAIN PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Recreation				
Facilities	Job	L.S.	-	$ 778,000
Real Estate, 2000 acres	Job	L.S.	-	637,000
Total, Recreation				1,415,000
Buildings, Grounds, Utilities				
Administration, Maintenance Building, etc.	Job	L.S.	-	25,000
Contingencies, approx. 25%				6,000
Total, Buildings, Grounds, Utilities				31,000
Engineering and Design				3,000
Supervision and Administration				3,000

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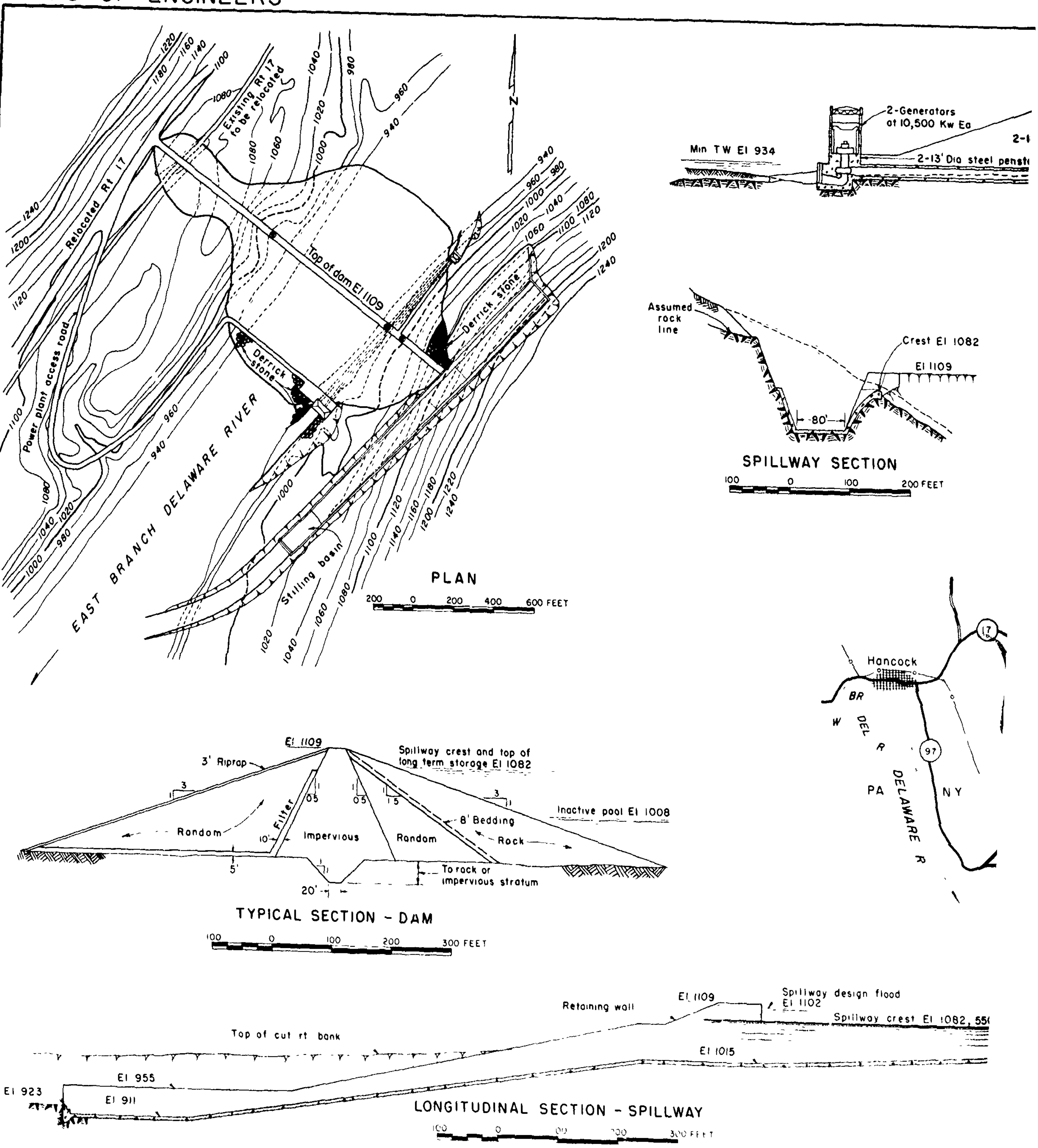
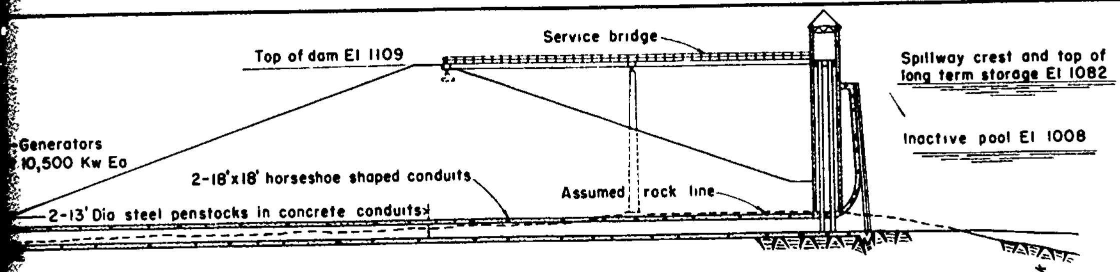
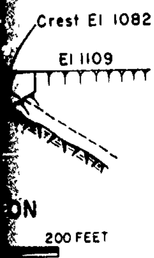
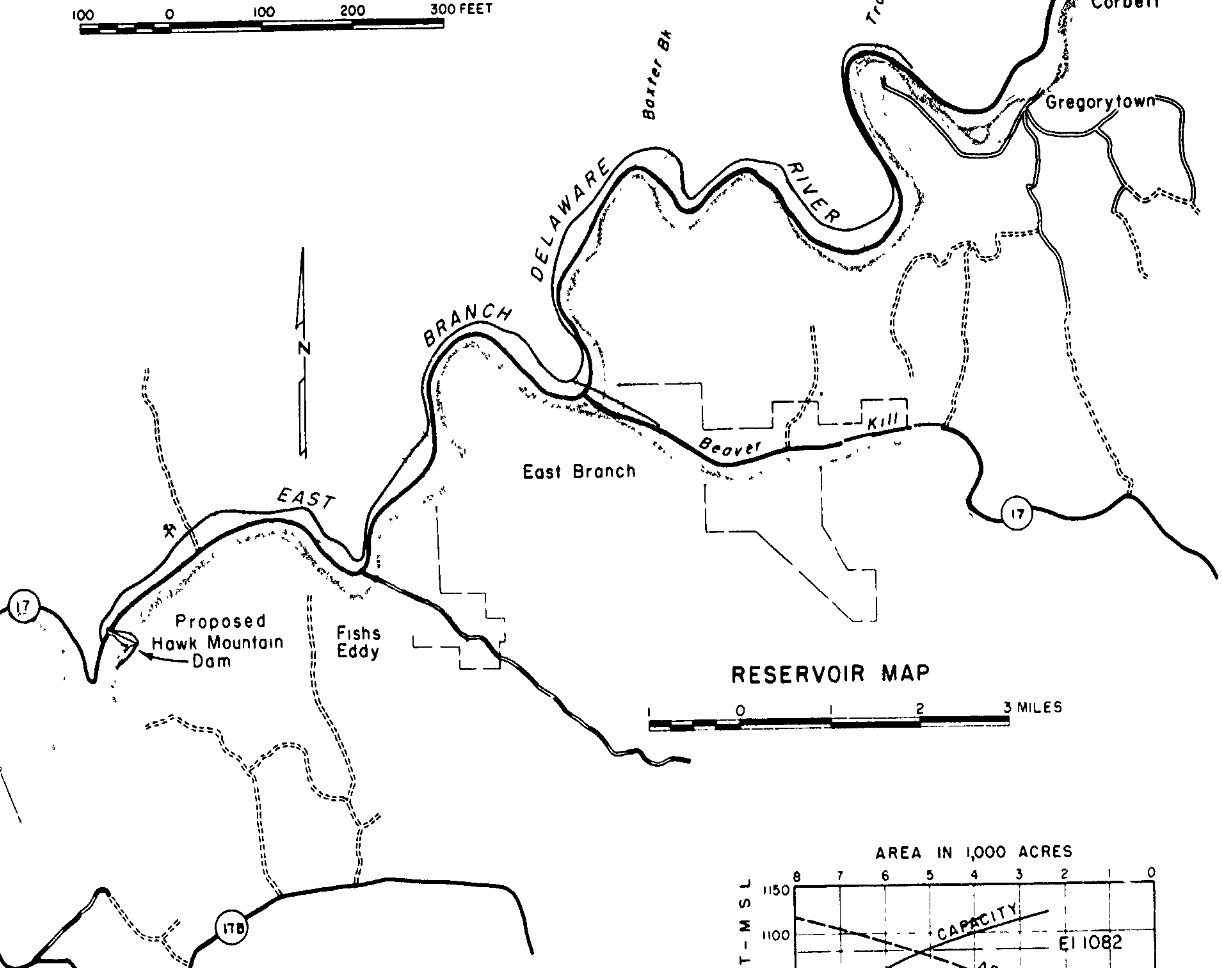


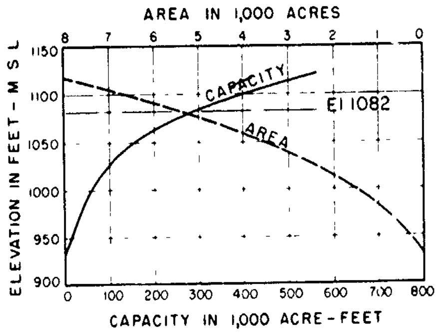


SECTION-OUTLET WORKS

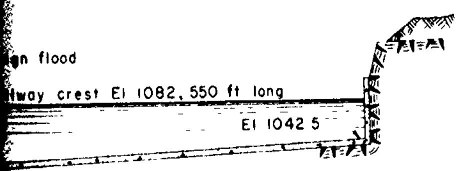




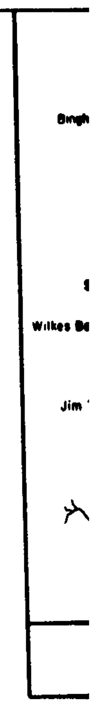
RESERVOIR MAP



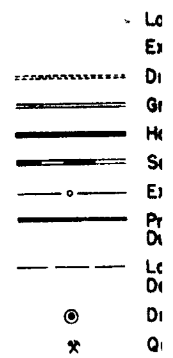
RESERVOIR AREA AND CAPACITY CURVES



SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Minimum Pool	1,008	60,000	1,500
Spillway Level	1,082	293,000	5,400



LEGEND



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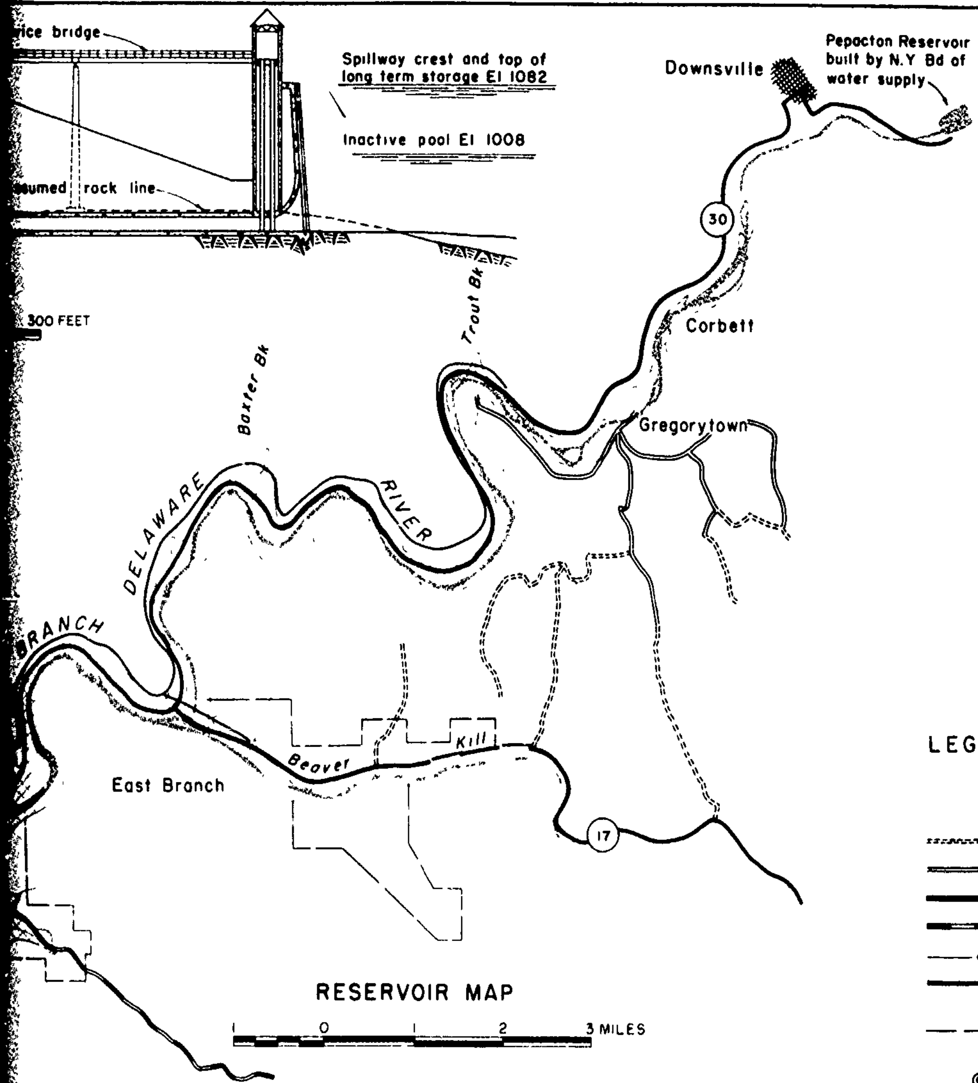
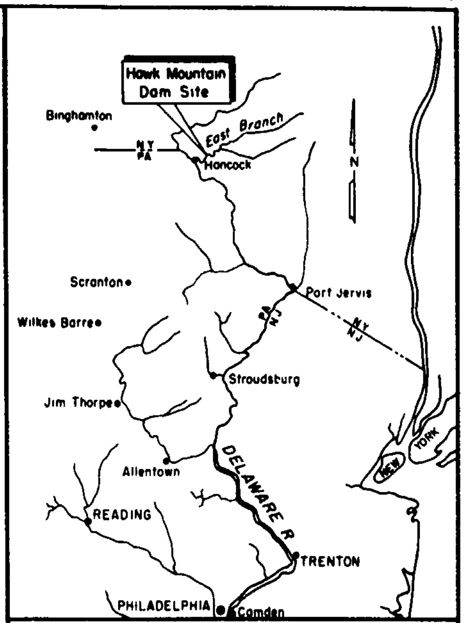


RESERVOIR MAP

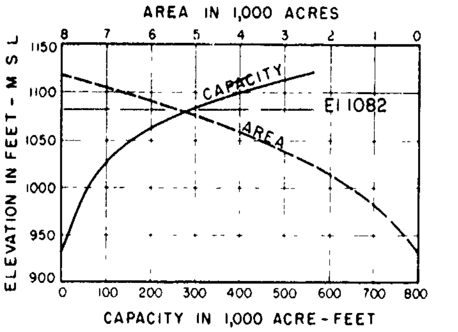


LOCATION MAP

SCALE

LEGEND

- Long Term Storage El 1082
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Petroleum Line
- Proposed Relocated Hard Surface Heavy Duty Road
- Land Acquisition for Recreation Development
- Drill Hole
- Quarry



RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Minimum Pool	1,008	60,000	1,500
Spillway Level	1,082	293,000	5,400

REVIEW REPORT DELAWARE RIVER BASIN

HAWK MOUNTAIN PROJECT

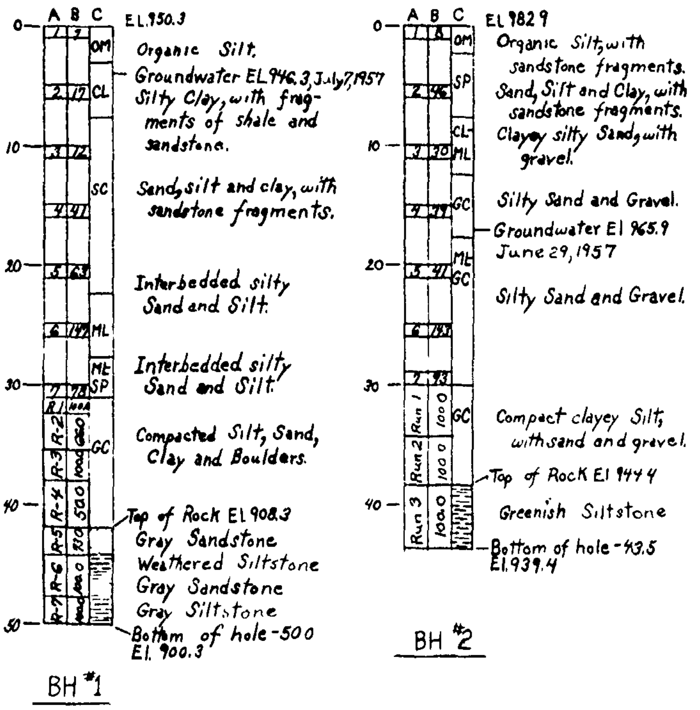
In 1 Sheet — Scale as Shown

Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

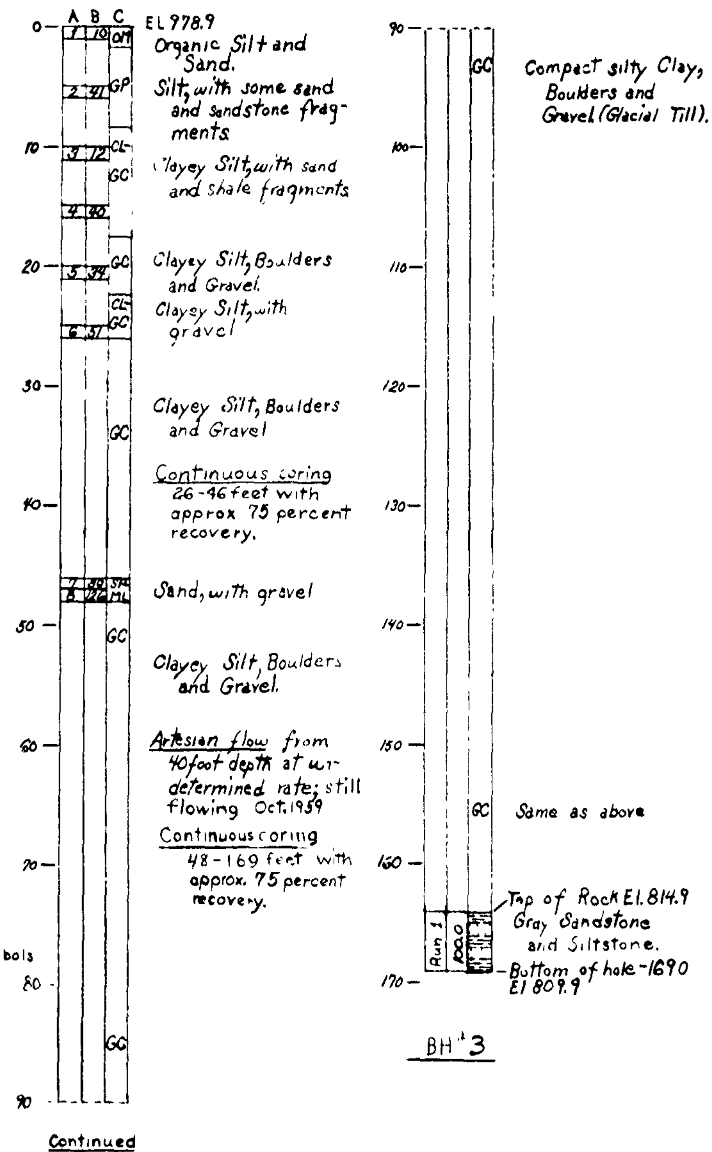
Drawer No 228 — File No 29124

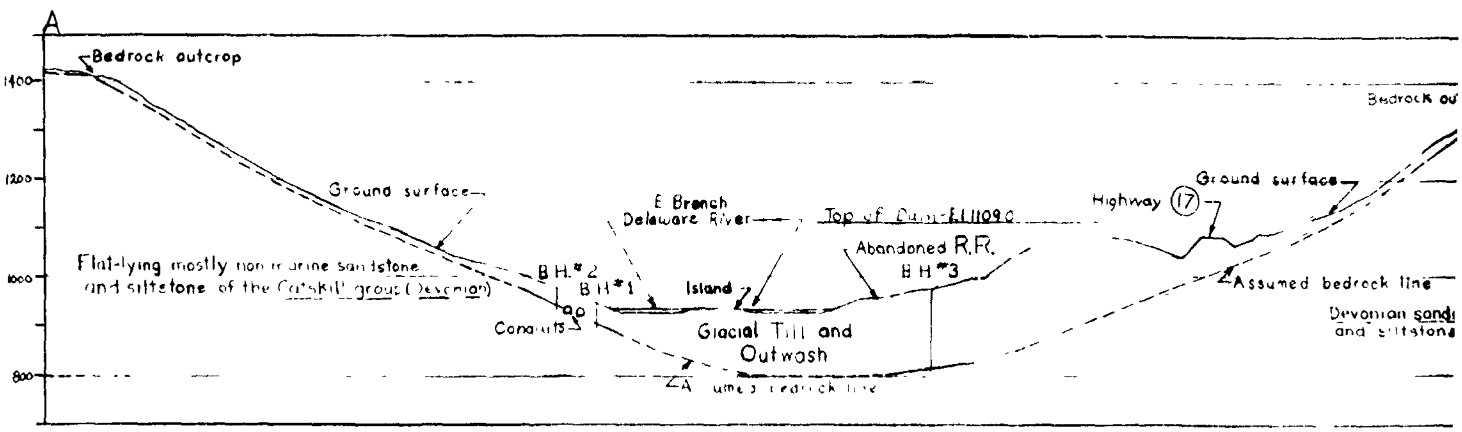
CORPS OF ENGINEERS



NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of spoon samples and core
2. Column "A" refers to the sample number or core run
3. Column "B" refers to the number of blows a 140 lb hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered, or the percent recovery of a specified core run
4. Column "C" is a field classification of the materials encountered, using the Unified Soils Classification System symbols, and graphic rock symbols
5. All elevations based on mean sea level datum
6. Drilling performed by Sprague and Henwood, Inc., Scranton, Pa., during June, July, 1957.





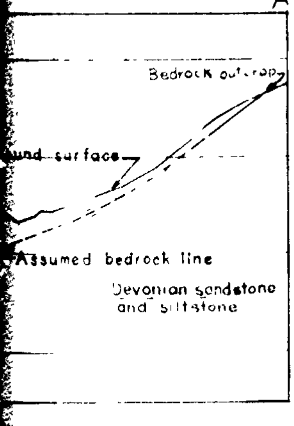
PROFILE ALONG SURVEYED AXIS OF DAM

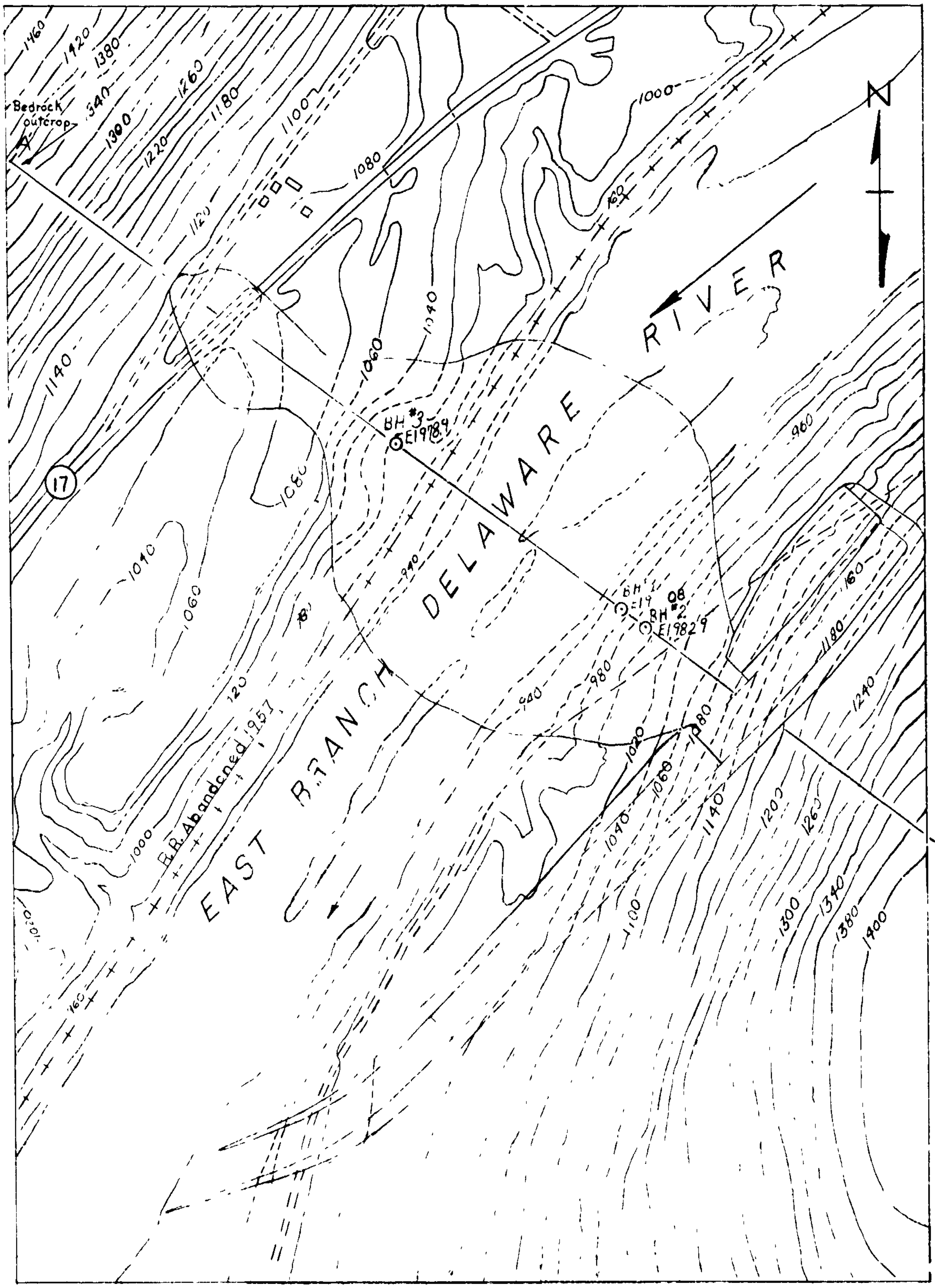
0 100 200 400 600 800 1000 Feet

Compact silty Clay,
Boulders and
Gravel (Glacial Till).

Same as above

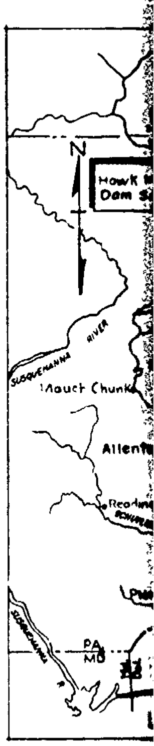
Top of Rock El. 814.9
Gray Sandstone
and Siltstone.
Bottom of hole -169.0
El. 809.9





SITE MAP

0 200 400 600 800 Feet



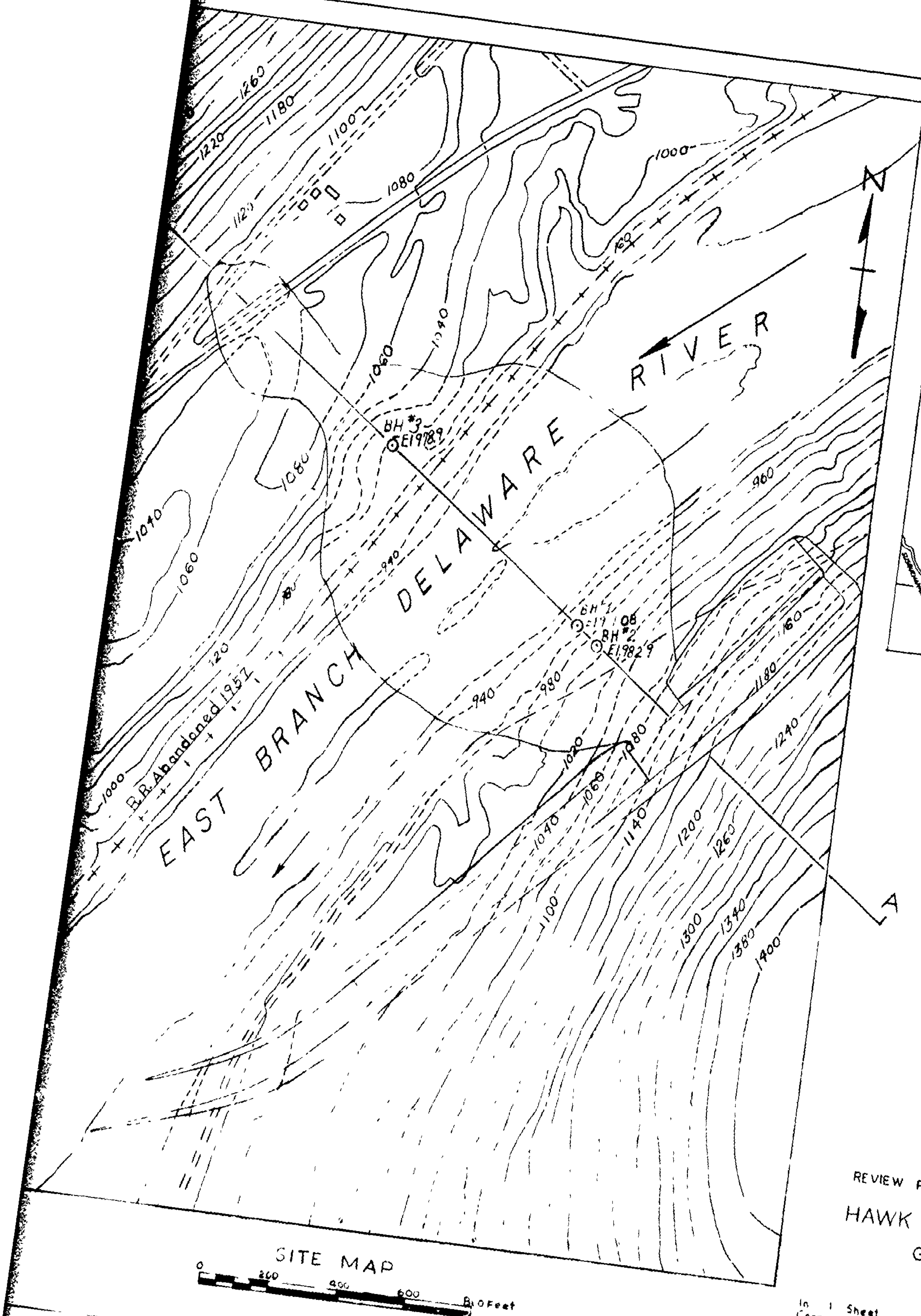
REVIEW R

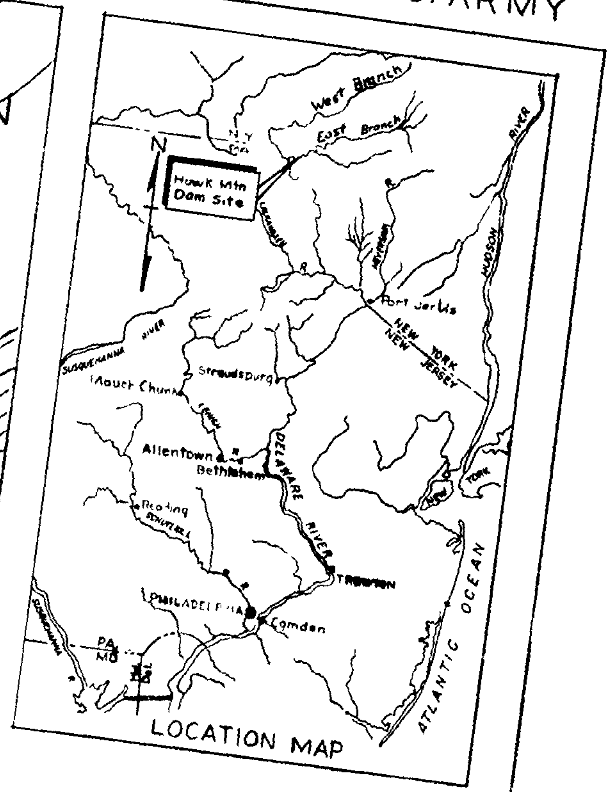
HAWK

In 1 Sheet
Corps of Engineers
Philadelphia, Pa.

Drawer No 228

U.S. ARMY





REVIEW REPORT DELAWARE RIVER BASIN

HAWK MOUNTAIN PROJECT

GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa.

Scales as Shown
Philadelphia District
13 Jan 60

Drawer No 228

File No 28911

PLATE 26

3

TABLE U-12

NEWARK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and Severance, 1090 ac.	job	l.s.	-	$ 309,000
Improvements, 24 units	"	"	-	321,000
Resettlement, 24 units	"	"	-	13,000
Easement, 50 ac.	"	"	-	10,000
Contingencies 15%				98,000
Acquisition	ownership	$ 700	32	23,000
Total Cost - Lands and Damages				774,000
Relocations				
Highways				
New graded County road	mile	125,000	2.4	300,000
New bridge & fill over reservoir (0.3 mi.)	job	l.s.	1	783,000
New bridge over White Clay Creek	job	l.s.	1	84,000
New bridge over West Branch of White Clay Creek	job	l.s.	1	84,000
Contingencies, approx. 25%				313,000
Subtotal, Highways				1,564,000
Utilities & Cemeteries				
Relocate service pole line	mile	5,000	2.7	14,000
Relocate stream gauging station	job	l.s.	1	30,000
Relocate water pumping plant	job	l.s.	1	100,000
Relocate interceptor sewer	mile	43,000	0.7	30,000
Relocate cemetery	job	l.s.	1	100,000
Contingencies, approx. 25%				69,000
Subtotal, Utilities and Cemeteries				343,000
Total, Relocations				1,907,000
Engineering and Design				172,000
Supervision and Administration				191,000

TABLE U-12

NEWARK PROJECT COST ESTIMATE

Description	Total Estimated Cost
Lands and damages	$ 774,000
Relocations	1,907,000
Reservoir Clearing	176,000
Dam and Appurtenant Works	5,700,000
Fish and Wildlife, mitigation of losses 1/	-
Access Road	37,000
Recreation, 2/	8,693,000
Buildings, Grounds, Utilities	31,000
Engineering and Design	707,000
Supervision and Administration	786,000
TOTAL PROJECT COST	$18,811,000

1/ Appendix J contains means of mitigating losses to stream fisheries, game habitat, and public hunting expected to be caused by the project. These means include the acquisition of public fishing rights and development of public use facilities along 8.5 miles of existing trout streams in Chester County, Pennsylvania, and New Castle County, Delaware, and in habitat improvement and public hunting opportunity on 650 acres of land needed in Chester County, Pennsylvania, and New Castle County, Delaware. The cost required to provide these mitigations is a project cost, and while omitted from the estimate above is taken into account in the economic analyses in Appendix V.
2/ This cost includes engineering, design, supervision and administration.

TABLE U-12

NEWARK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Lands and Damages				
Land and Severance, 1090 ac.	job	l.s.	-	$ 309,000
Improvements, 24 units	"	"	-	321,000
Resettlement, 24 units	"	"	-	13,000
Easement, 50 ac.	"	"	-	10,000
Contingencies 15%				98,000
Acquisition	ownership	$ 700	32	23,000
Total Cost - Lands and Damages				774,000
Relocations				
Highways				
New graded County road	mile	125,000	2.4	300,000
New bridge & fill over reservoir (0.3 mi.)	job	l.s.	1	783,000
New bridge over White Clay Creek	job	l.s.	1	84,000
New bridge over West Branch of White Clay Creek	job	l.s.	1	84,000
Contingencies, approx. 25%				313,000
Subtotal, Highways				1,564,000
Utilities & Cemeteries				
Relocate service pole line	mile	5,000	2.7	14,000
Relocate stream gauging station	job	l.s.	1	30,000
Relocate water pumping plant	job	l.s.	1	100,000
Relocate interceptor sewer	mile	43,000	0.7	30,000
Relocate cemetery	job	l.s.	1	100,000
Contingencies, approx. 25%				69,000
Subtotal, Utilities and Cemeteries				343,000
Total, Relocations				1,907,000
Engineering and Design				172,000
Supervision and Administration				191,000

TABLE U-12

NEWARK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Reservoir Clearing				
Agricultural land	acre	$80	560	$ 45,000
Pastureland	acre	80	120	10,000
Woodland, light clearing	acre	80	90	7,000
Woodland, medium clearing	acre	210	185	39,000
Woodland, heavy clearing	acre	350	95	33,000
Residential and industrial	acre	50	40	2,000
Farm units	each	500	5	3,000
Residential units	each	75	18	1,000
Churches, schools, commercial etc.	each	200	4	1,000
Contingencies, approx. 25%				35,000
Total - Reservoir Clearing				176,000
Engineering & Design				16,000
Supervision & Administration				18,000
Dam and Appurtenant Works				
Clearing & grubbing	acre	600	5.0	3,000
Diversion & care of river	job	l.s.		100,000
Excavation, common	c.y.	1.00	32,000	32,000
Excavation, rock	c.y.	5.00	21,000	105,000
Line drilling	s.f.	4.00	10,000	40,000
Drilling & placing anchors	l.f.	10,00	400	4,000
Foundation preparation	s.y.	7.00	9,000	63,000
Drilling and pressure grouting	l.f.	8.00	6,000	48,000
Drilling drain holes, 3" dia.	l.f.	11.00	2,000	22,000
Concrete mass	c.y.	22.00	140,000	3,080,000
Concrete training walls	c.v.	35.00	3,200	112,000
Concrete parapet walls	c.y.	75.00	200	15,000
Cement	bbl.	6.00	143,000	858,000
Reinforcing steel	lb.	0.18	500,000	90,000
Rubber water stops	l.f.	3.00	3,000	9,000
Miscellaneous metal	lb.	0.60	60,000	36,000
Backfill	c.y.	1.20	4,000	5,000
Riprap & derrick stone	c.y.	3.00	1,000	3,000

TABLE U-12

NEWARK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Dam and Appurtenant Works - Continued				
Sluice gates	lb.	$0.60	90,000	$ 54,000
Handrailing	l.f.	4.00	250	1,000
Gate operating system	job	l.s.	-	10,000
Bypass system	job	l.s.	-	15,000
Floatwell and drainage s't'm.	job	l.s.	-	12,000
Lighting and power system	job	l.s.	-	10,000
Heating and ventilating s't'm.	job	l.s.	-	5,000
Standby electric generator	job	l.s.	-	4,000
Chain hoist, 1-1/2 ton capacity	job	l.s.	-	1,000
Tile gage	job	l.s.	-	3,000
Adit house	job	l.s.		10,000
Contingencies, approx. 20%				950,000
Total, Dam and Appurtenant Works				5,700,000
Engineering and Design				513,000
Supervision & Administration				570,000
Access Road				
New road	mile	120,000	0.25	30,000
Contingencies, approx 25%				7,000
Total, Access Road				37,000
Engineering and Design				3,000
Supervision & Administration				4,000
Recreation				
Facilities 1/	job	l.s.	-	4,042,000
Real Estate, 5400 ac.	job	"	-	4,651,000
Total, Recreation				8,693,000

1/ Includes contingencies, engineering, design, supervision and administration

TABLE U-12

NEWARK PROJECT COST ESTIMATE

Description	Unit	Unit Price	Quantity	Cost
Building, Grounds, Utilities				
Administration, Maintenance Building, etc.	job	l.s.		$ 25,000
Contingencies, approx. 25%				6,000
Total, Building, Grounds, Utilities				31,000
Engineering and Design				3,000
Supervision & Administration				3,000

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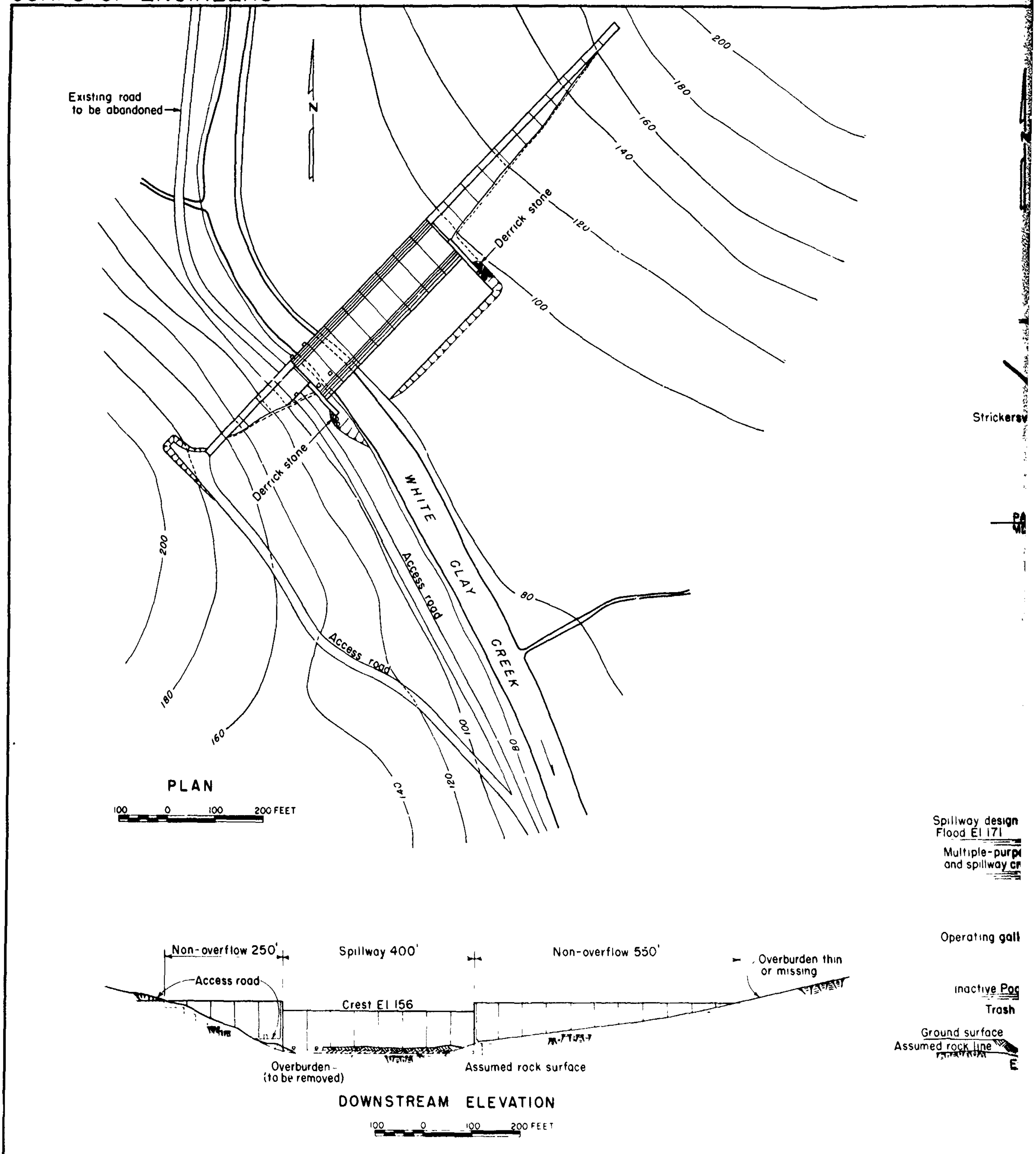
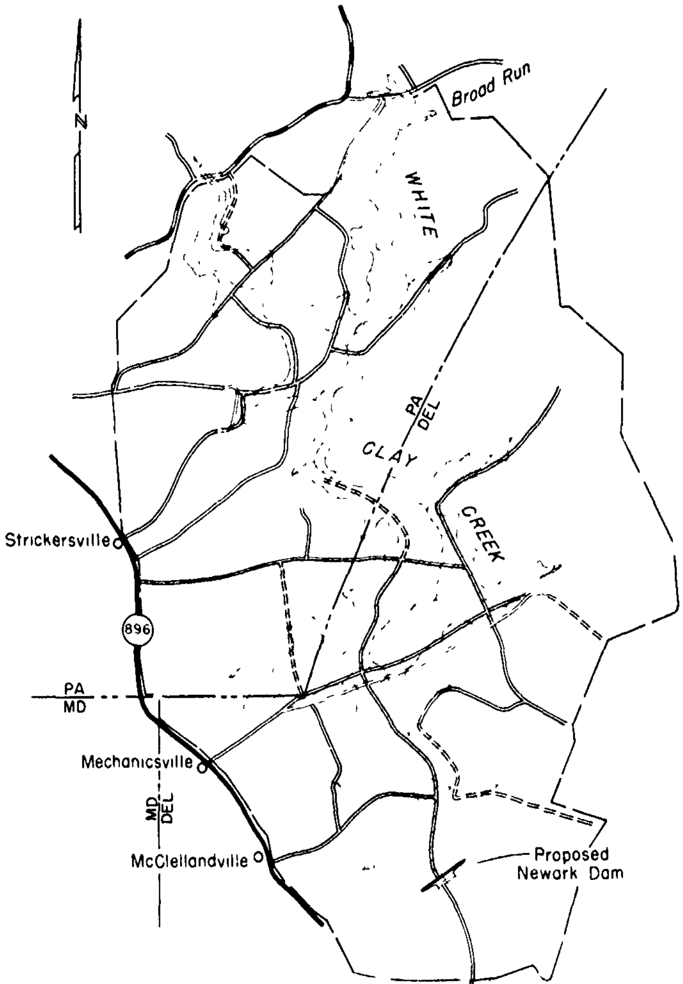
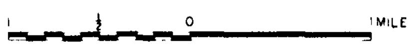
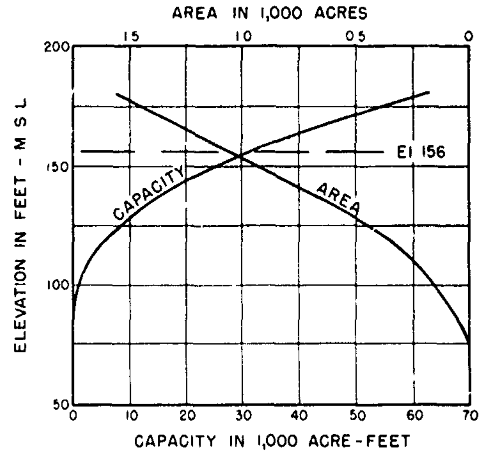




RESERVOIR MAP

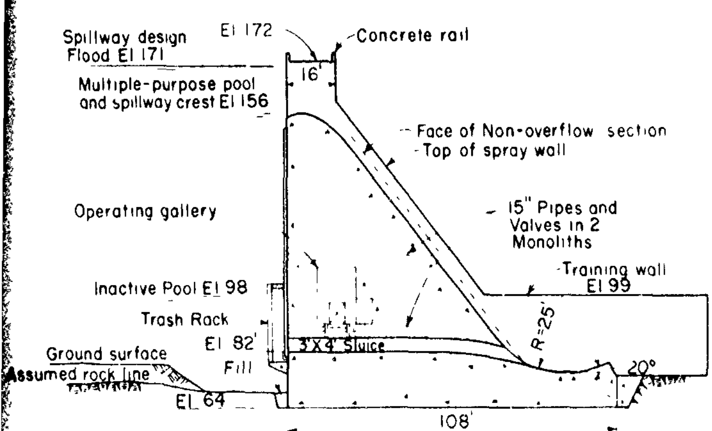




RESERVOIR AREA AND CAPACITY CURVES

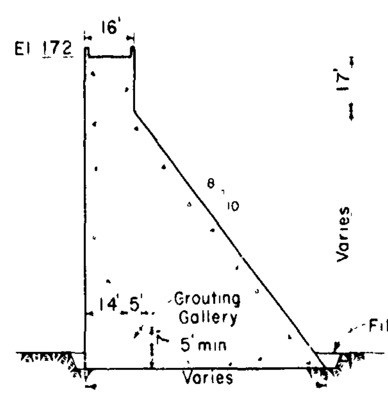
LEGEND

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple - Purpose Pool	156	31,000	1,060



SPILLWAY SECTION

20 0 20 40 FEET



TYPICAL SECTION NON-OVERFLOW DAM

20 0 20 40 FEET

REVIEW

In 1 Sheet

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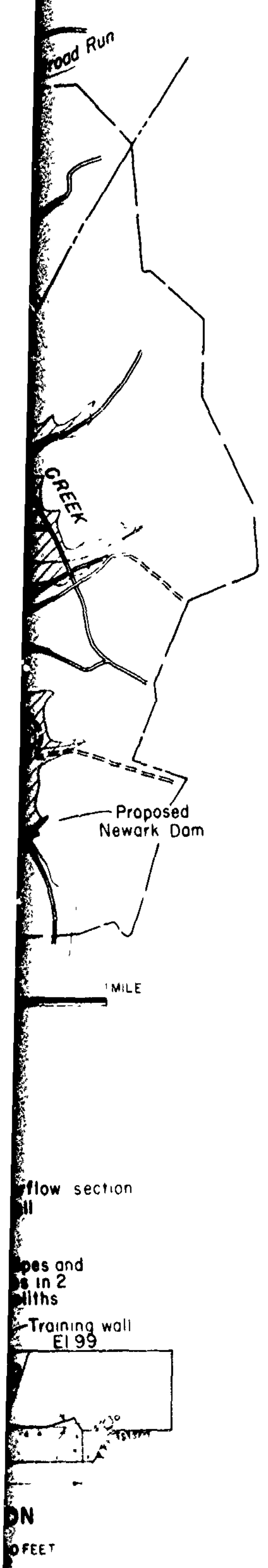
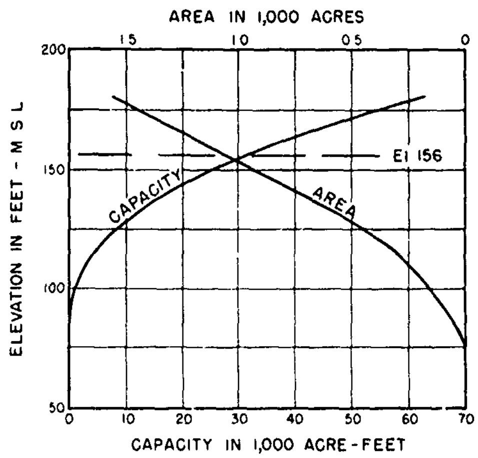
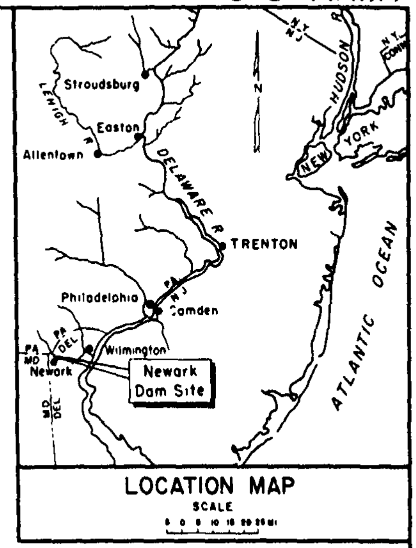




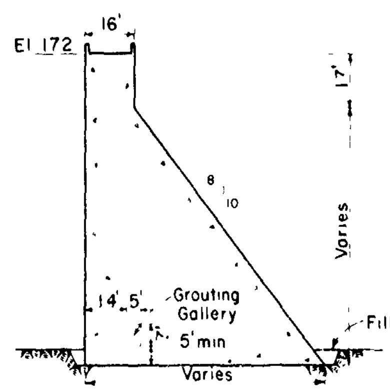
RESERVOIR AREA AND CAPACITY CURVES



LEGEND

- Multiple-Purpose Pool El 156
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Proposed Relocated Graded Road
- Land Acquisition for Recreation Development

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple - Purpose Pool	156	31,000	1,060



TYPICAL SECTION NON-OVERFLOW DAM

20 0 20 40 FEET

REVIEW REPORT DELAWARE RIVER BASIN

NEWARK PROJECT

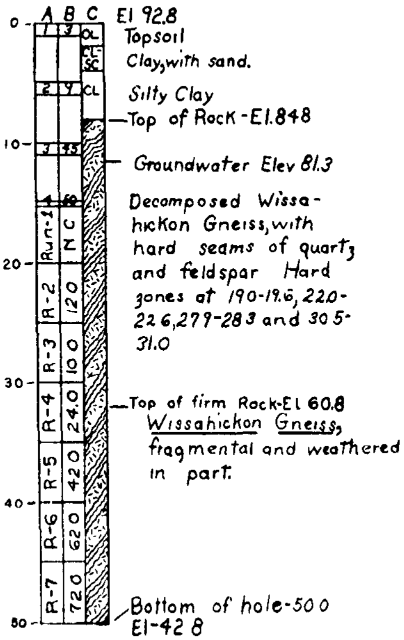
In 1 Sheet — Scale as Shown

Corps of Engineers
Philadelphia, Pa

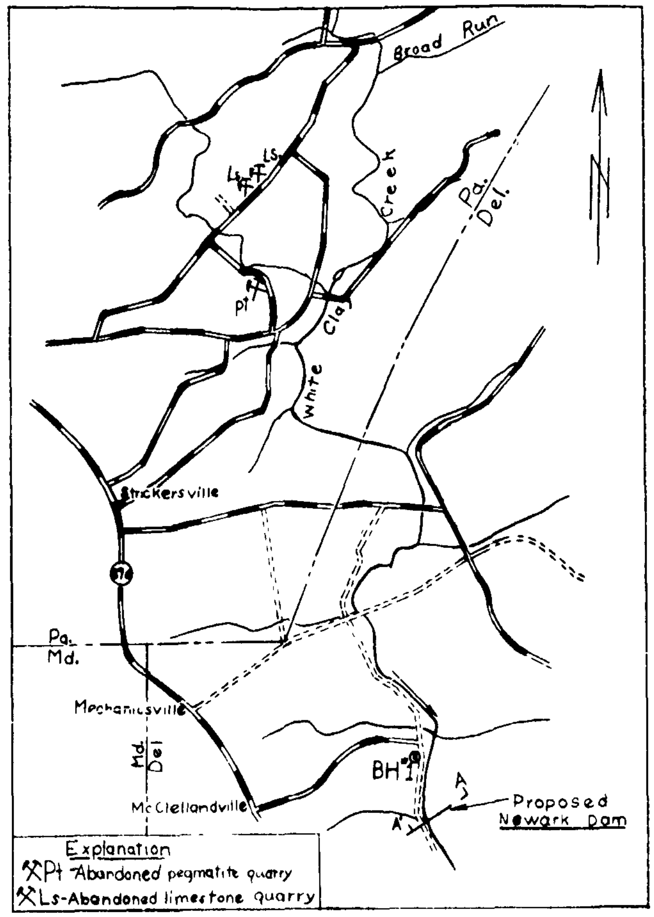
Philadelphia District
June 1960

Drawer No 228 — File No 29118

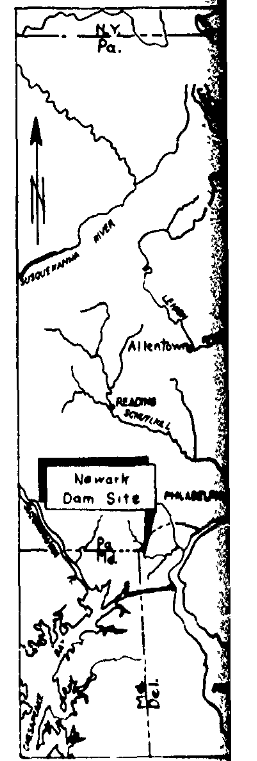
CORPS OF ENGINEERS



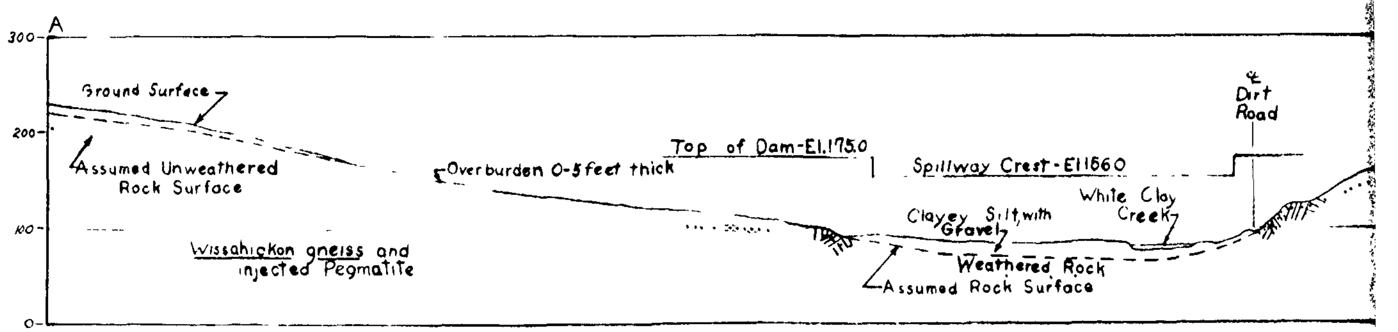
BH*1



RESERVOIR MAP



LOCA



PROFILE ALONG LINE A-A'

NOTES.

1. Descriptions of materials encountered in borings are based on visual inspection of spoon samples and core.
2. Column "A" refers to the sample number and core run.
3. Column "B" refers to the number of blows a 140 lb hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered or percent core recovery.
4. Column "C" is a field classification of the materials encountered, using the Unified Soils Classification System symbols and graphic rock symbols.
5. All elevations based on mean sea level datum.
6. Boring by Walton Well Drilling, Inc., Newark, Delaware, in Nov 1959.
7. Weathered zone on profile based on information from borings by Walton Well Drilling, Inc 2000 feet up stream.

REVIEW REPORT

NEWAR
GEOLO

In 1 Sheet
Corps of Engineers
Philadelphia, Pa.

Drawer No. 228

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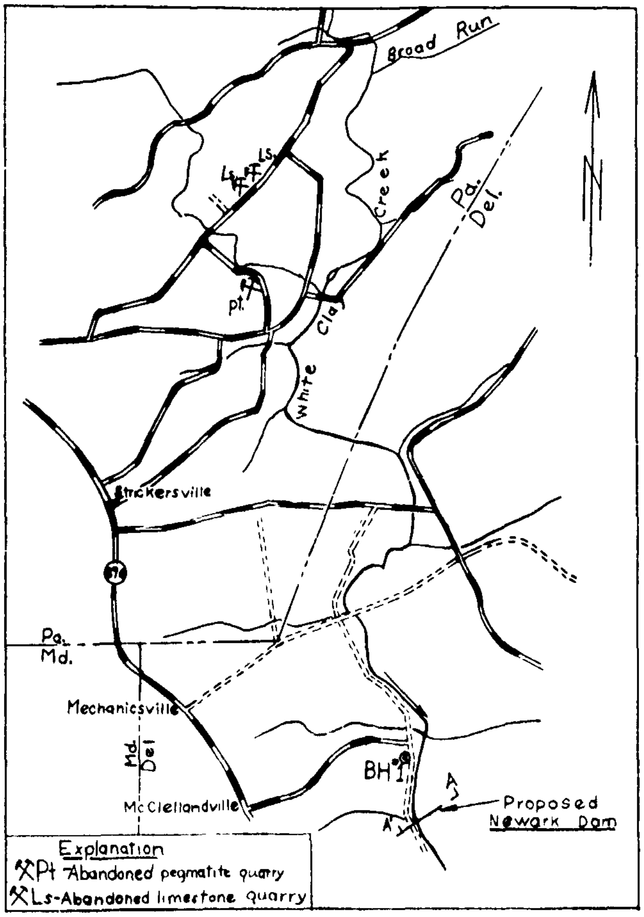
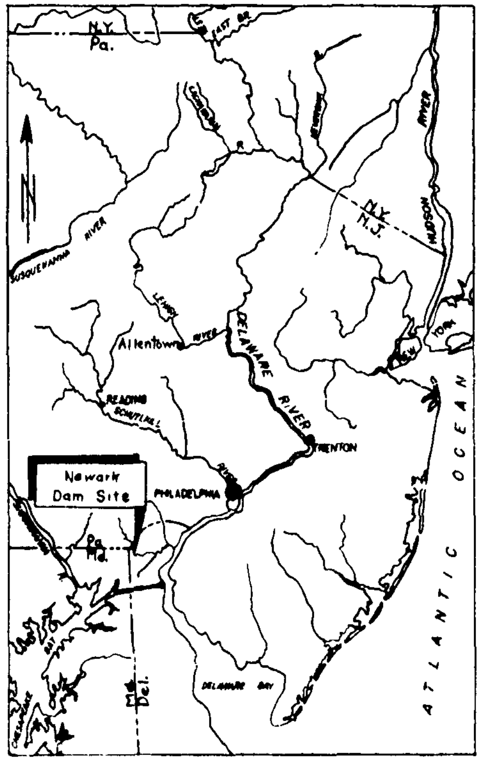
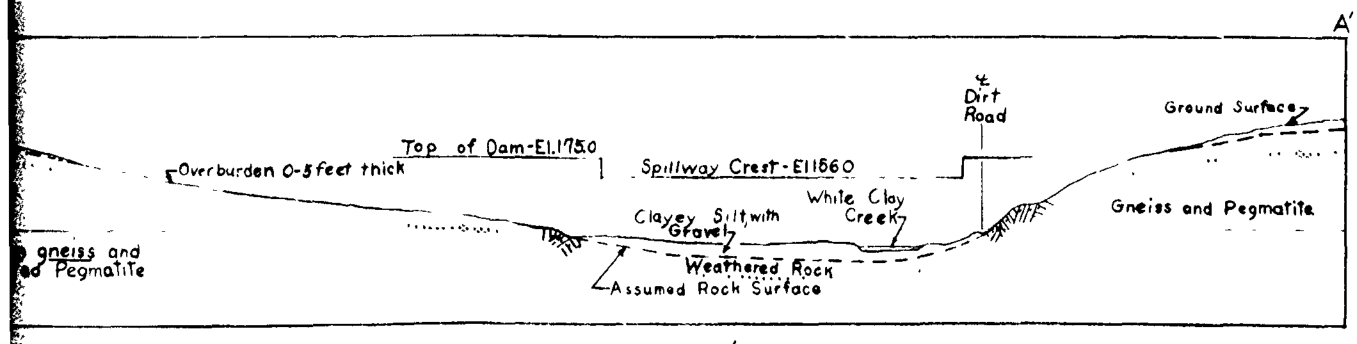


RESERVOIR MAP

0 ½ 1 2 Miles



LOCATION MAP



PROFILE ALONG LINE A-A'

0 50 100 200 300 400 500 FT.

...tered in borings are based
...amples and core
... number and core run
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...o push the sampling spoon
... encountered or percent

...ation of the materials encountered,
...ication System symbols, and graphic rock symbols.

...n sea level datum.

6 Boring by Walton Well Drilling, Inc., Newark, Delaware, in Nov 1959.

7. Weathered zone on profile based on information from borings by Walton Well Drilling, Inc 2000 feet up stream.

REVIEW REPORT DELAWARE RIVER BASIN

NEWARK PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
24 Jan. 60

Drawer No. 228

File No 29085

34. Evansburg Project

a. The Evansburg project fully developed would provide facilities for water supply, recreation and other purposes. The full development would be required some time after the year 2010. To preserve the site, it is proposed that land be acquired as it becomes available and be put to immediate use for recreation purposes.

b. The dam would be located across the valley of Skippack Creek about a mile above its confluence with Perkiomen Creek and about two miles southeast of Collegeville, Pennsylvania. The drainage area above this site is 54 square miles. Data on basic dimensions of the project at its ultimate development are as follows:

Capacity
Long term, 25,000 ac.-ft., stream bed to elevation 166

Elevations
Top of dam, 183
Spillway crest, 166
Outlet, upstream invert, 104
Stream bed at dam, 97

Area
Reservoir at elevation 166, 1,120 acres

c. At the dam site the stream has cut a nearly vertical bank at the right (west) abutment in the siltstone and shale bedrock. In the valley and on the left abutment, bedrock is covered with a shallow overburden of red sandy clay. Seventeen drill holes and auger borings were made in vicinity of the dam site, as shown on plate 30, to determine the location, extent and quality of nearby earth materials for the dam. No borings to determine location or type of bedrock were considered necessary because of the numerous rock outcrops in the area.

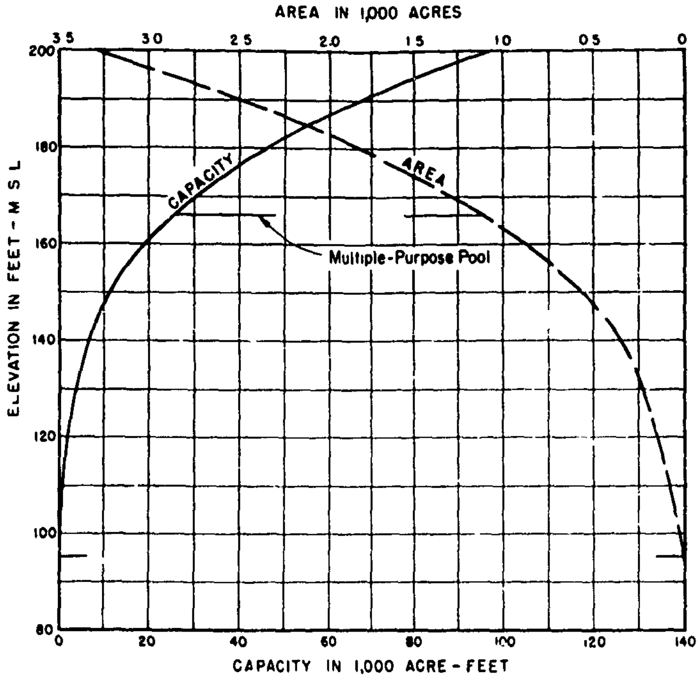
d. The dam, for which the cost estimate was made, would be an earth embankment up to elevation 183 (approximately 86 feet high), 1,270 feet long with a spillway 200 feet wide across the ridge that forms the left abutment. Material for the embankment would come from three sources: spillway excavation, borrow areas along existing roads about 1/2 mile northwest of the dam site, and a sandstone quarry about 1/2 mile upstream from the dam site. An 11-foot diameter concrete conduit at about stream bed elevation would provide for diversion during construction and controlled reservoir releases thereafter.

e. The reservoir created by this dam (up to the spillway crest, elevation 166) would be 69 feet deep at the dam and would extend about eight miles upstream. It would make necessary the

relocation or raising of some county roads, three state highways and the reconstruction of a few transmission line towers. The only commercially valuable mineral deposit in the reservoir area is one medium-sized quarry which is being worked for a limited production of sandstone facing.

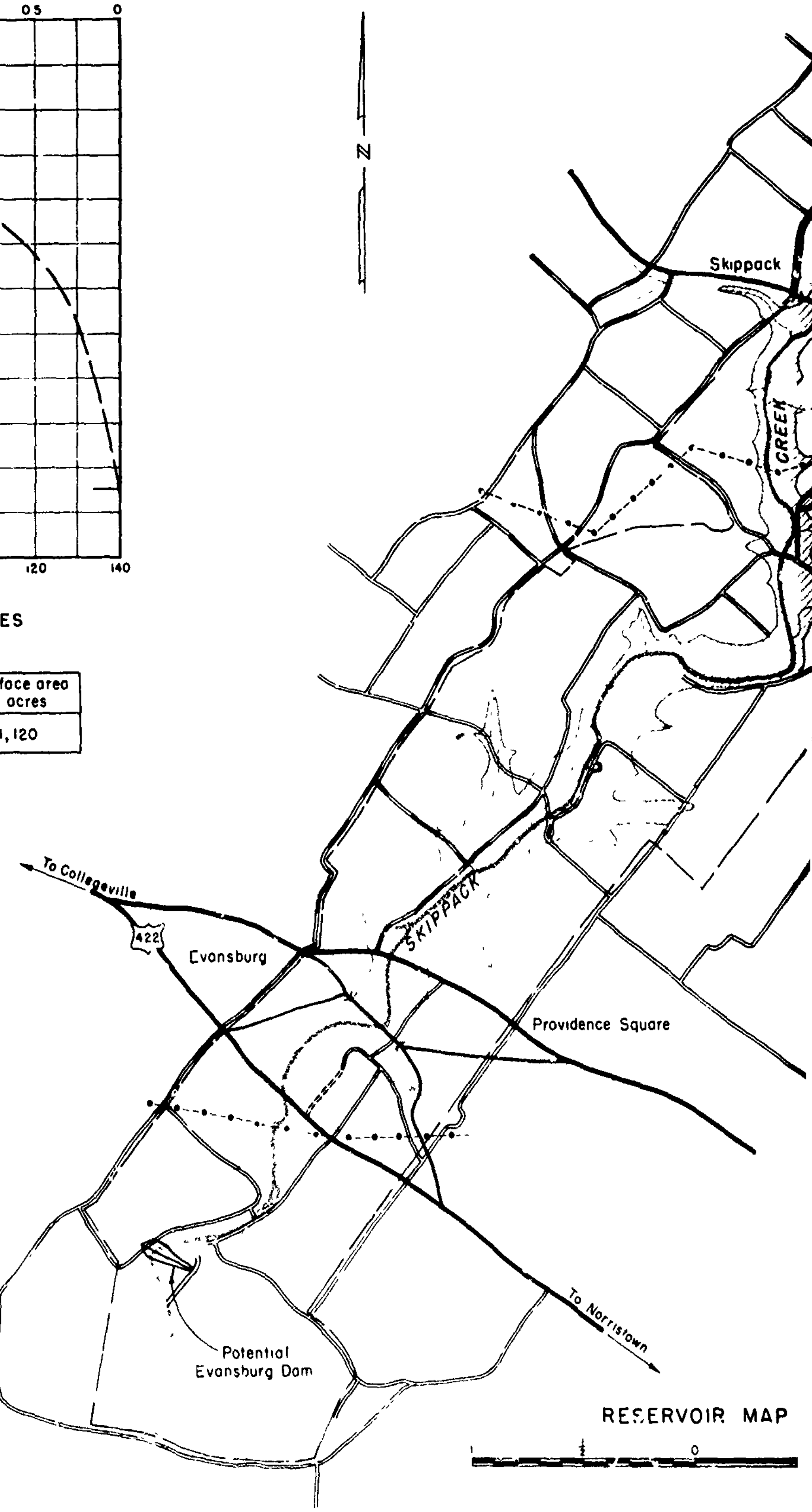
f. The estimated cost of the development, as described, is 23.8 million dollars. This estimate includes 4.3 million dollars for acquiring the reservoir land area to preserve it for future use and 12.0 million dollars of specific recreation costs comprised of 6.7 million dollars for land and 5.3 million dollars for recreation facilities. The remaining 7.5 million dollars is the estimated cost of the dam and appurtenant works, relocations, and reservoir clearing if the project were constructed as proposed herein.

CORPS OF ENGINEERS



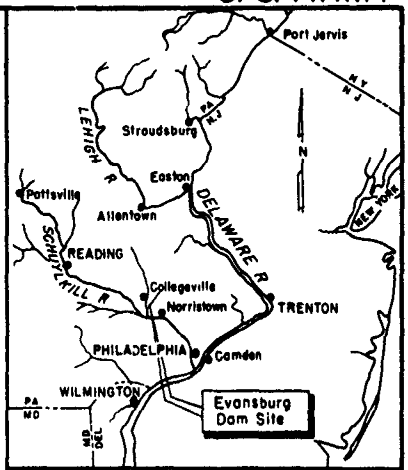
RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	166	25,000	1,120



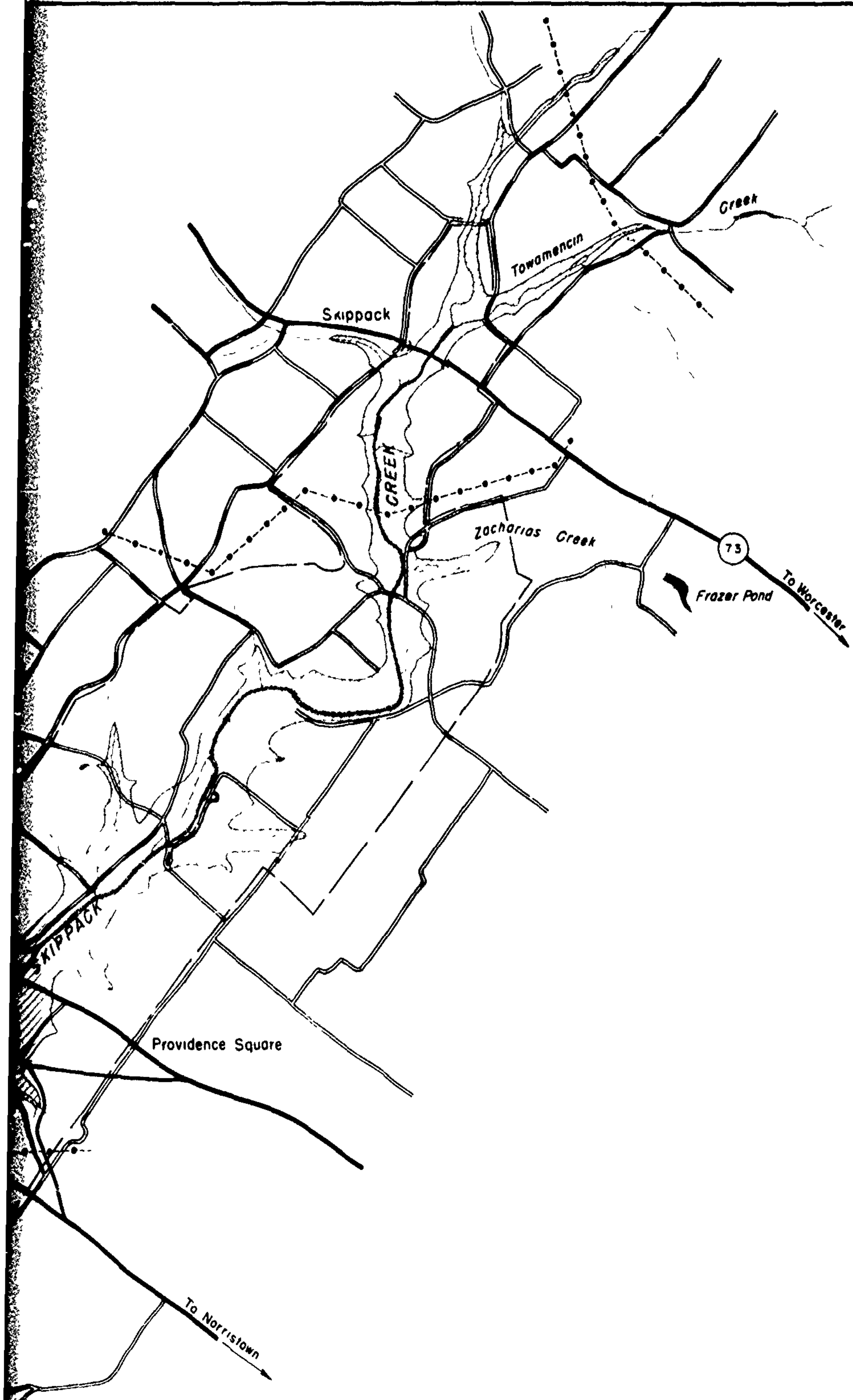
RESERVOIR MAP

U. S. ARMY



LOCATION MAP

SCALE



RESERVOIR MAP

1 ½ 0 1 MILE

LEGEND

- Multiple-Purpose Pool El. 166
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Power Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Reinforced Power Line
- Land Acquisition for Recreation Development

REVIEW REPORT DELAWARE RIVER BASIN

EVANSBURG PROJECT

In 1 Sheet

Scale as Shown

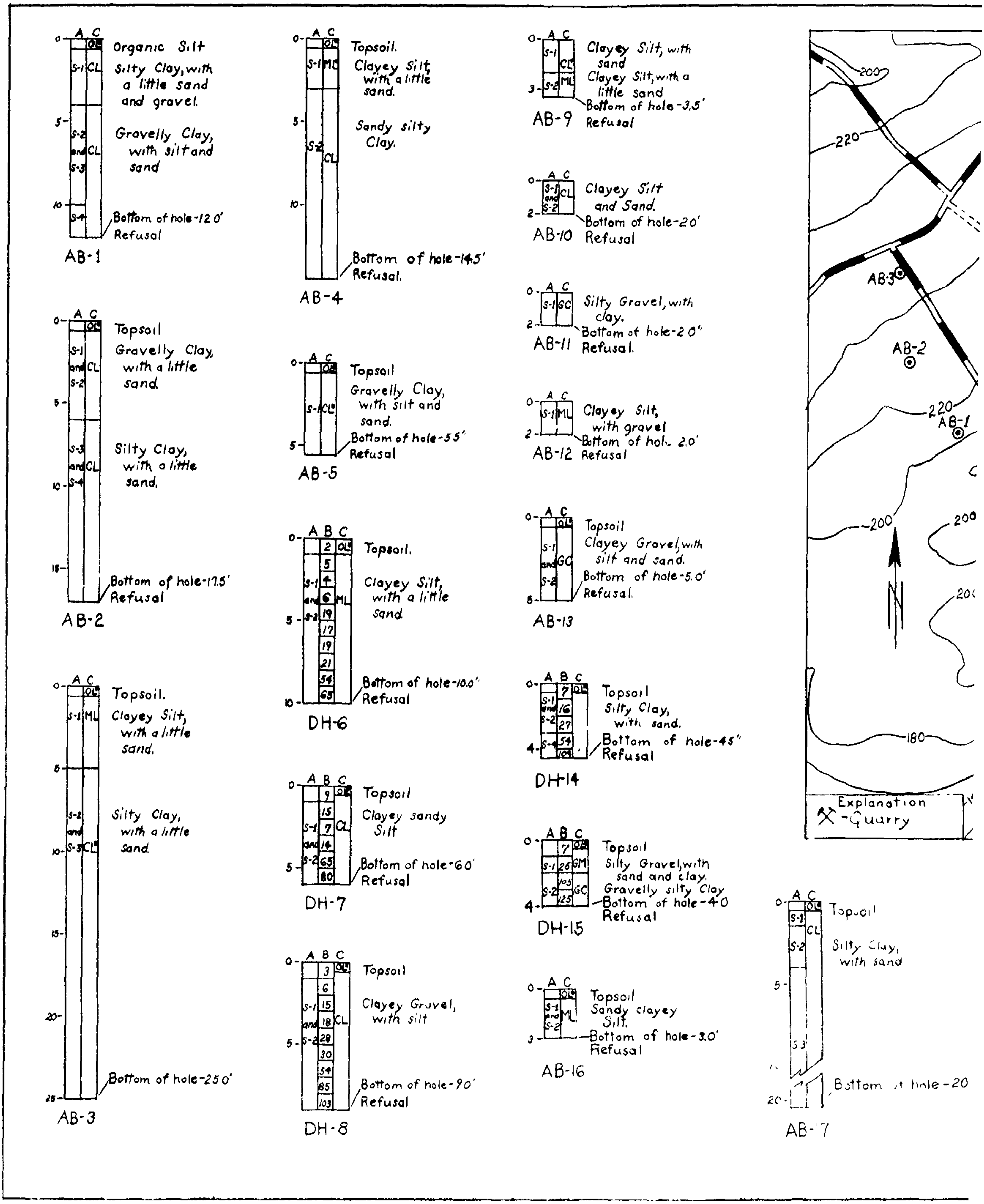
Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

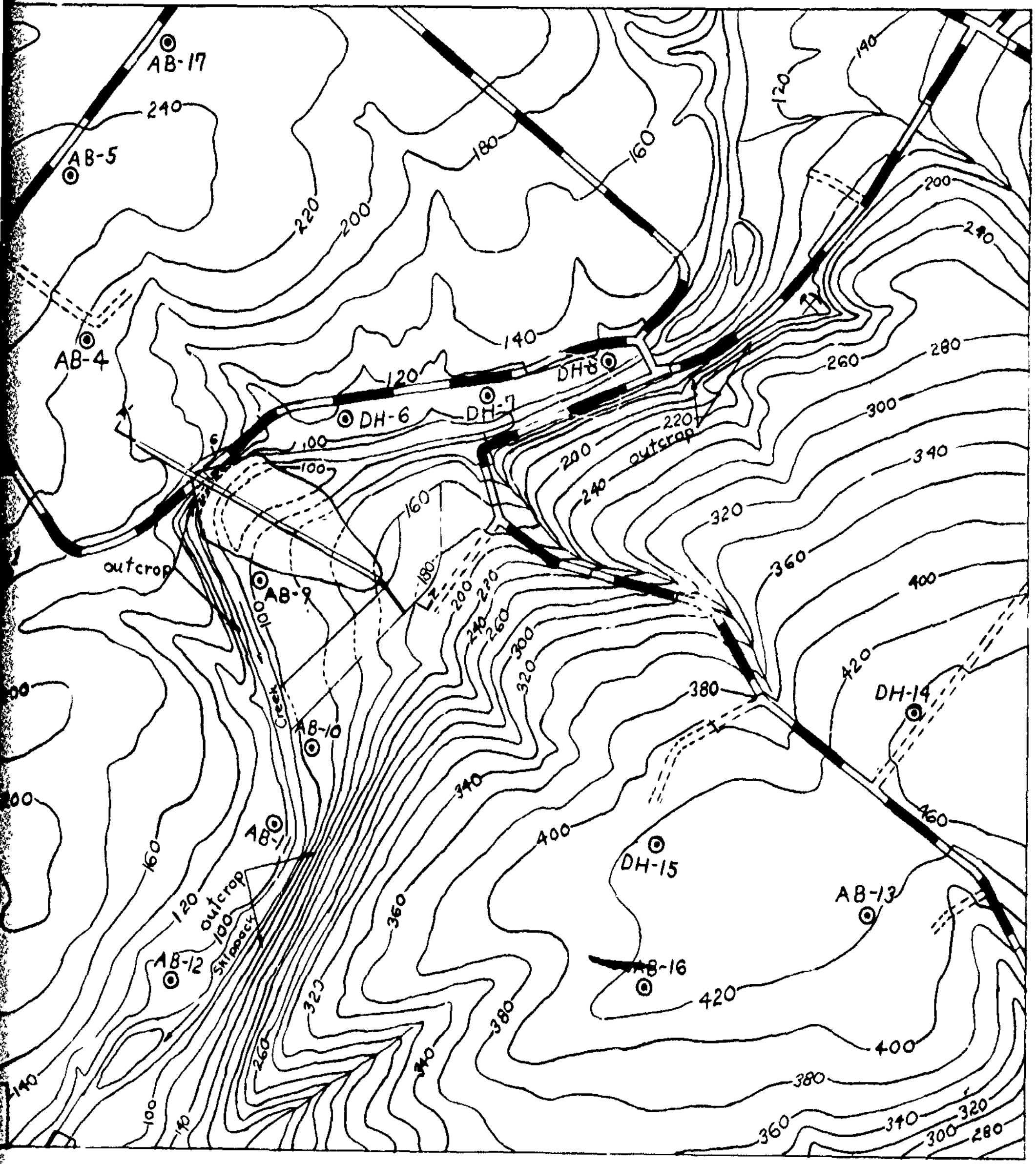
Drawer No 228

File No 29116

CORPS OF ENGINEERS

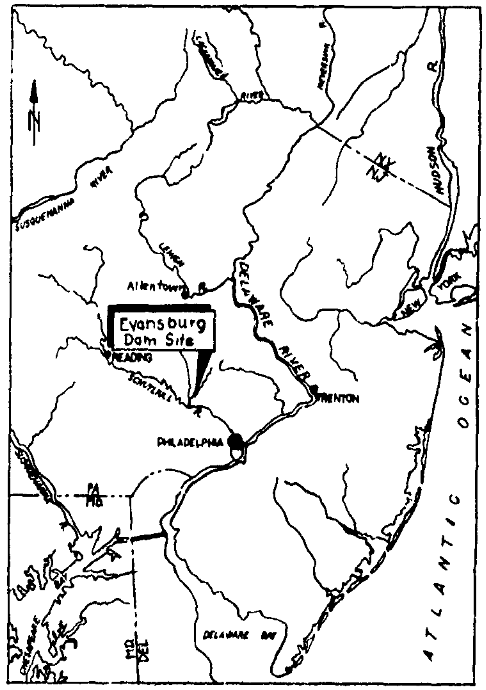


U. S. ARMY



SITE MAP

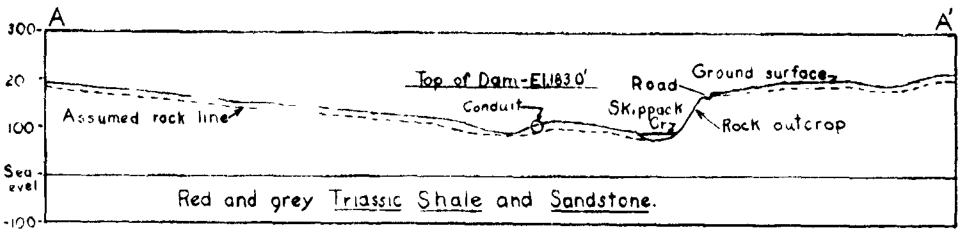
0 500 1000 1500 2000 2500 FT.



LOCATION MAP

NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of samples
2. Column "A" refers to the sample number
3. Column "B" refers to the number of blows a 300 lb hammer dropping 18 inches required to push the 5ft by 3½ in Sand H sampling spoon (J) one foot into the materials encountered.
4. Column "C" is a lab classification of the materials using the Unified Soils Classification System symbols. Asterisk (*) denotes field or visual classification
5. The letter designations at the bottom of each log stand for the following—
   AB - auger boring
   DH - drill hole
6. —indicates direction of strike and dip of beds in degrees
7. Water table not encountered in most holes, not measured in others due to short life of hole.
8. Borings not made on dam axis due to outcropping rock and thin overburden.
9. Borings by NAB in April, 1959
10. Borings have not been surveyed, locations are approximate.



PROFILE ALONG LINE A-A'

0 100 200 400 600 800 1000FT

REVIEW REPORT DELAWARE RIVER BASIN

EVANSBURG PROJECT
GEOLOGIC DATA AND
BORROW INVESTIGATION

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
25 Nov 59

Drawer No 228

File No. 29084

PLATE 3

35. French Creek Project

a. The French Creek project fully developed would provide facilities for water supply, recreation and other purposes. The full development would be required some time after 2010. To preserve the site it is proposed that land be acquired as it becomes available and be put to immediate recreation purposes.

b. The dam would be located about 9.5 miles above the mouth of French Creek and 8 miles west of Phoenixville, Pennsylvania. The drainage area upstream from the dam is 47 square miles. Data on basic dimensions of the project at its ultimate development are as follows:

Capacity
Long term, 27,000 ac.-ft., stream bed to elevation 289

Elevations
Top of dam, 305
Spillway crest, 289
Outlet, upstream invert, 218
Stream bed at dam, 214

Area
Reservoir at elevation 289, 1,250 acres

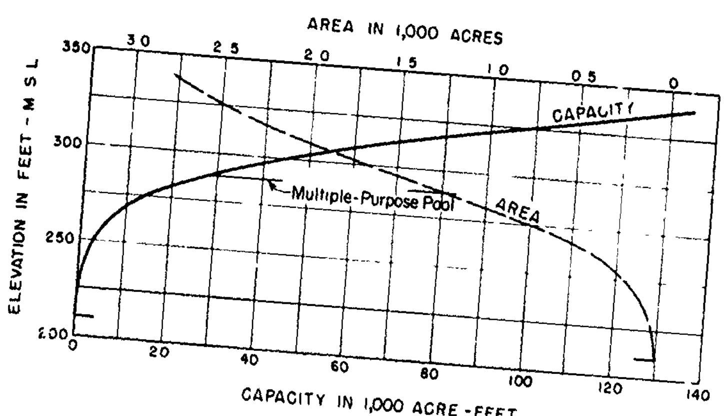
c. The creek at the dam site follows the contact between pre-Cambrian gneiss and quartz monzonite in the right (south) abutment and onlapping Triassic sandstone and shale in the left (north) abutment. The shallow overburden consists of clayey silt and sandy clay. A Triassic diabase dike crosses the axis near the spillway and has invaded and altered the neighboring rocks. This dike and the data from four test borings are shown on Plate 32.

d. The dam, for which the cost estimate was made, would be an earth embankment 3,000 feet long with a 30-foot wide top at elevation 305 feet (approximately 91 feet above the stream bed). Material for the dam would be obtained from the spillway excavation and from borrow areas in vicinity of the spillway inlet. The 340-foot wide unlined spillway would pass flood flows around the left end of the embankment. Diversion and outlet would be accomplished by a 12.5-foot diameter conduit at stream bed on the left abutment.

e. The reservoir created by this dam (up to the spillway crest at elevation 289 feet) would be 75 feet deep at the dam and would extend eight miles upstream. Construction of the reservoir would make it necessary to relocate portions of two state highways, several county roads, a gas pipeline and the communities of Pughtown and Coventryville. No commercially valuable mineral deposits exist in the reservoir area.

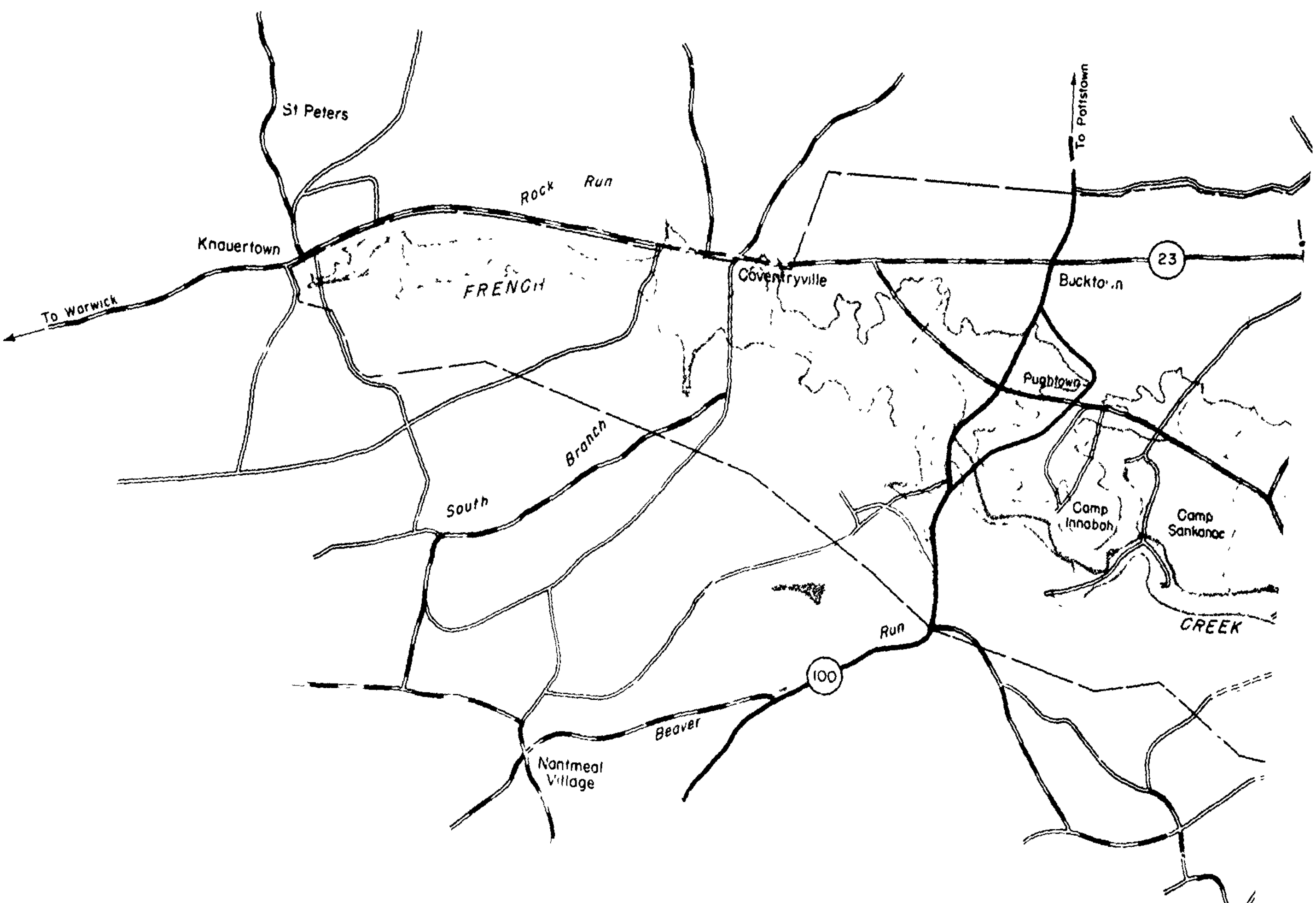
f. The estimated cost of the development, as described, is 18.7 million dollars. This estimate includes 3.0 million dollars for acquiring the reservoir to preserve it for future use and 9.1 million dollars of specific recreation costs comprised of 3.9 million dollars for land and 5.2 million dollars for recreation facilities. The remaining 6.6 million dollars is the estimated cost of the dam and appurtenant works, relocations, and reservoir clearing if the project were constructed as proposed herein.

CORPS OF ENGINEERS



RESERVOIR AREA AND CAPACITY CURVES

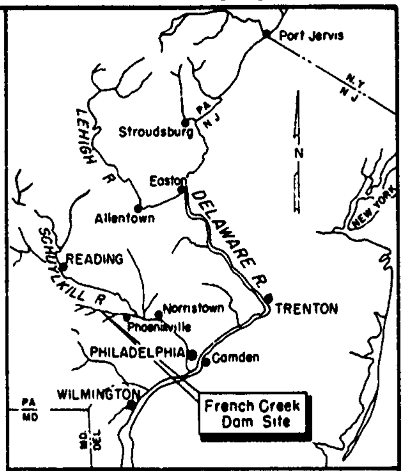
SCHEME	Pool elevation	Capacity in acre-feet	Surface in acr
Multiple - Purpose Pool	289	27,000	1,25C



RESERVOIR MAP

1 ½ 0 1 MILE

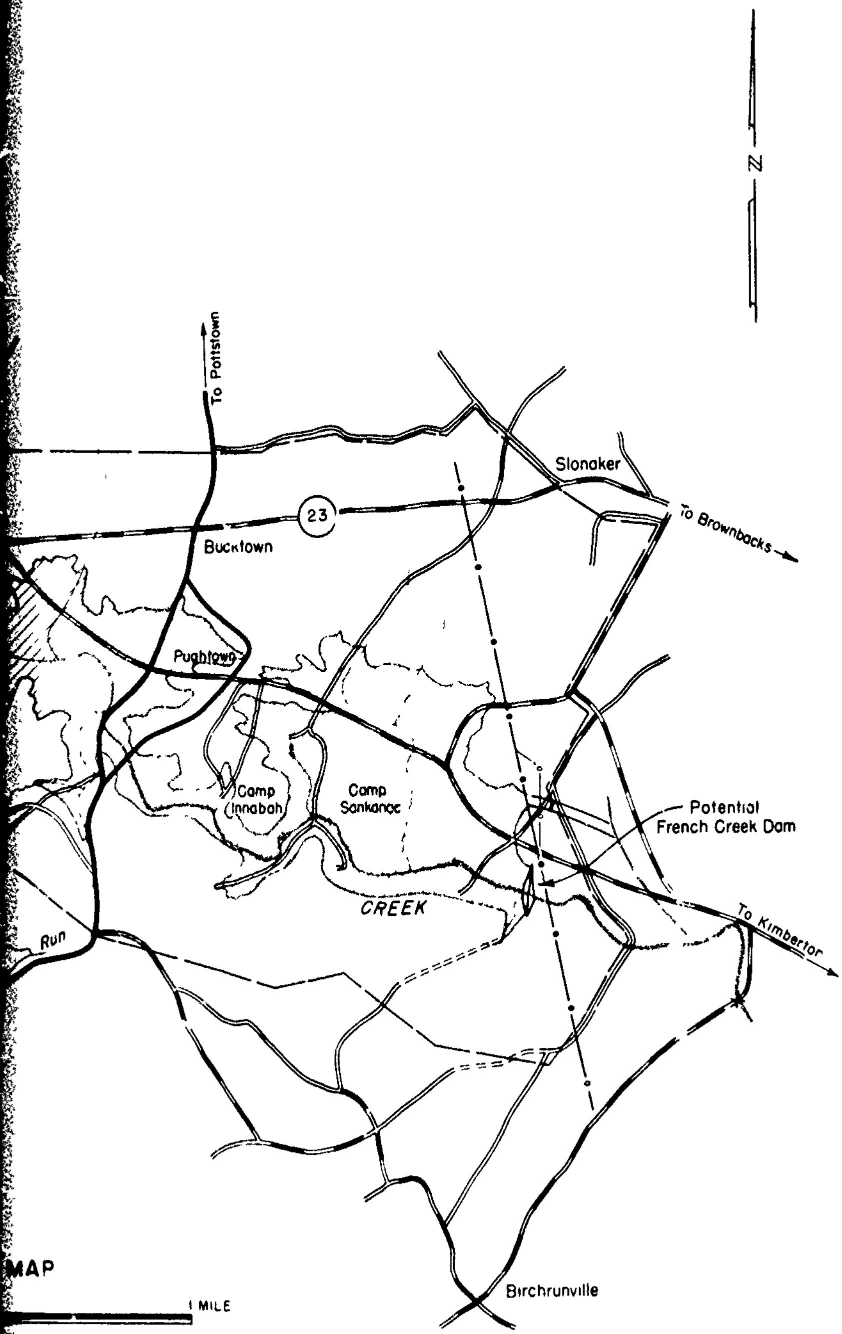
U. S. ARMY



LOCATION MAP

SCALE

SCHEME	P(' elevation	Capacity in acre-feet	Surface area in acres
...ple - Purpose	289	27,000	1,250



MAP

LEGEND

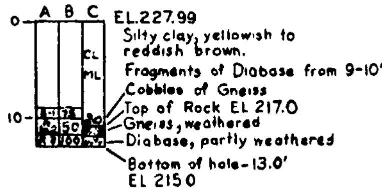
- Multiple-Purpose Pool El 289
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Gas Pipe Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Gas Pipe Line
- Land Acquisition for Recreation Development

REVIEW REPORT DELAWARE RIVER BASIN

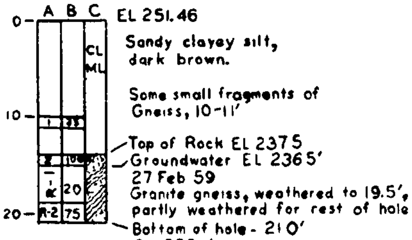
FRENCH CREEK PROJECT

In 1 Sheet	Scale as Shown
Corps of Engineers Philadelphia, Pa	Philadelphia District June 1960
Drawer No 228	File No 29114

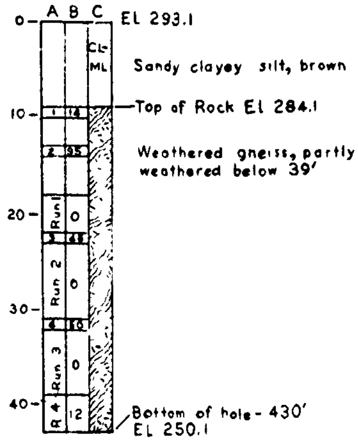
CORPS OF ENGINEERS



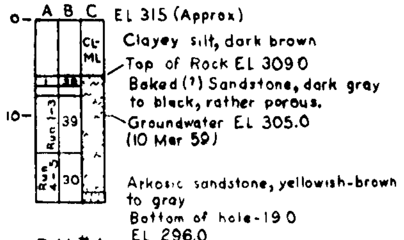
B.H.#1



B.H.#2



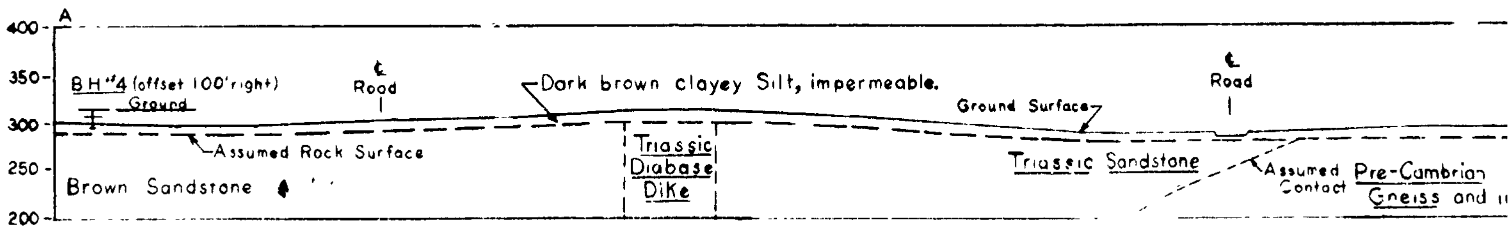
B H #3



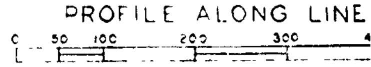
B.H.#4

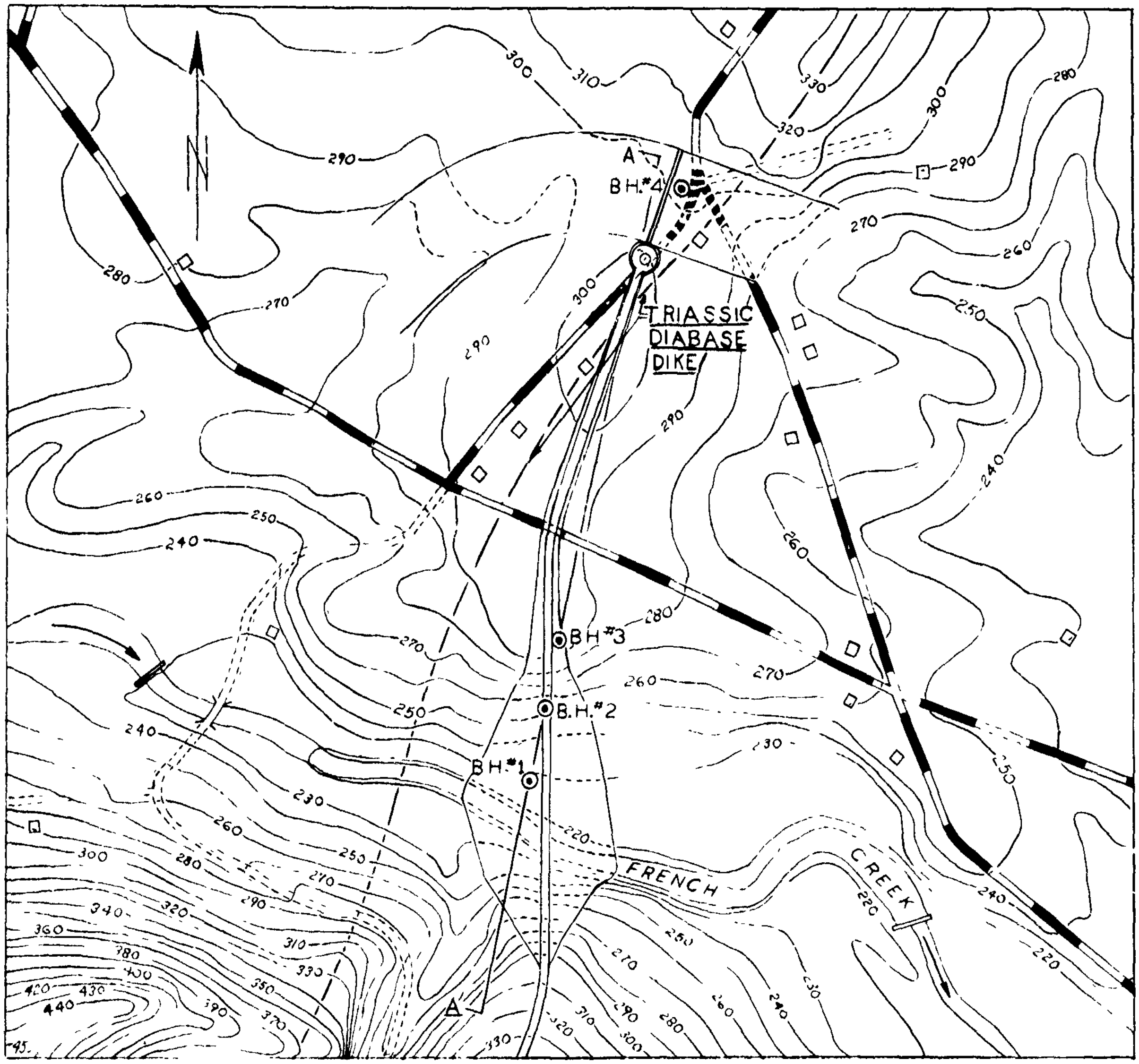
NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of cuttings, spoon and core samples
2. Numbers in column "A" indicate drive samples or core run
3. Column "B" indicates blow count for one (1) foot penetration by standard split spoon using 140 lb weight, with an 18 inch drop, or percent recovery for the interval shown
4. Column "C" indicates field classification of the materials encountered using the Unified Soils Classification System symbols and graphic rock symbols
5. All elevations based on mean sea level
6. Work performed by Corps of Engineers, Phila. Dist, during February, March 1959

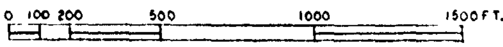


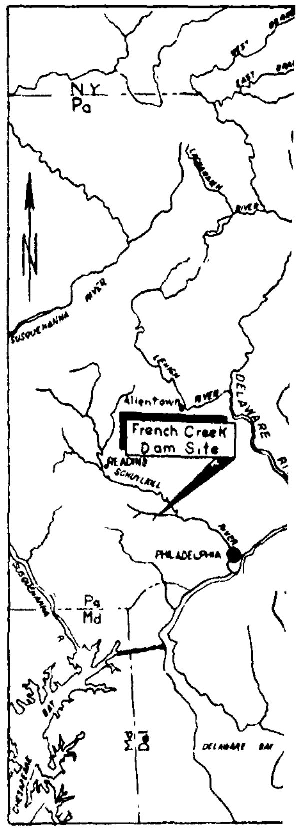
PROFILE ALONG LINE



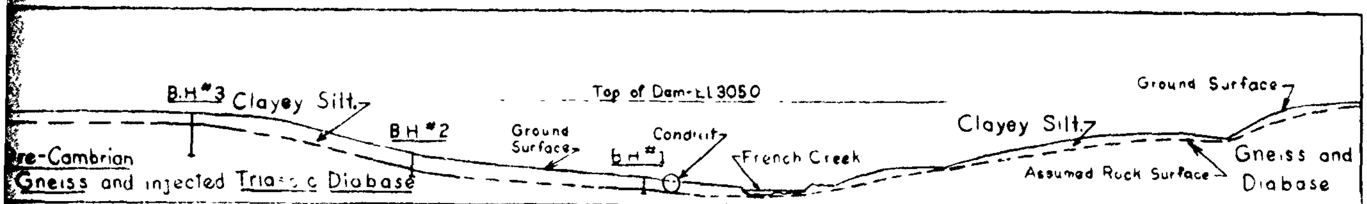


SITE MAP

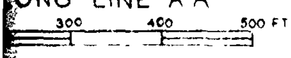




LOCATION



ONG LINE A-A'



REVIEW REPORT

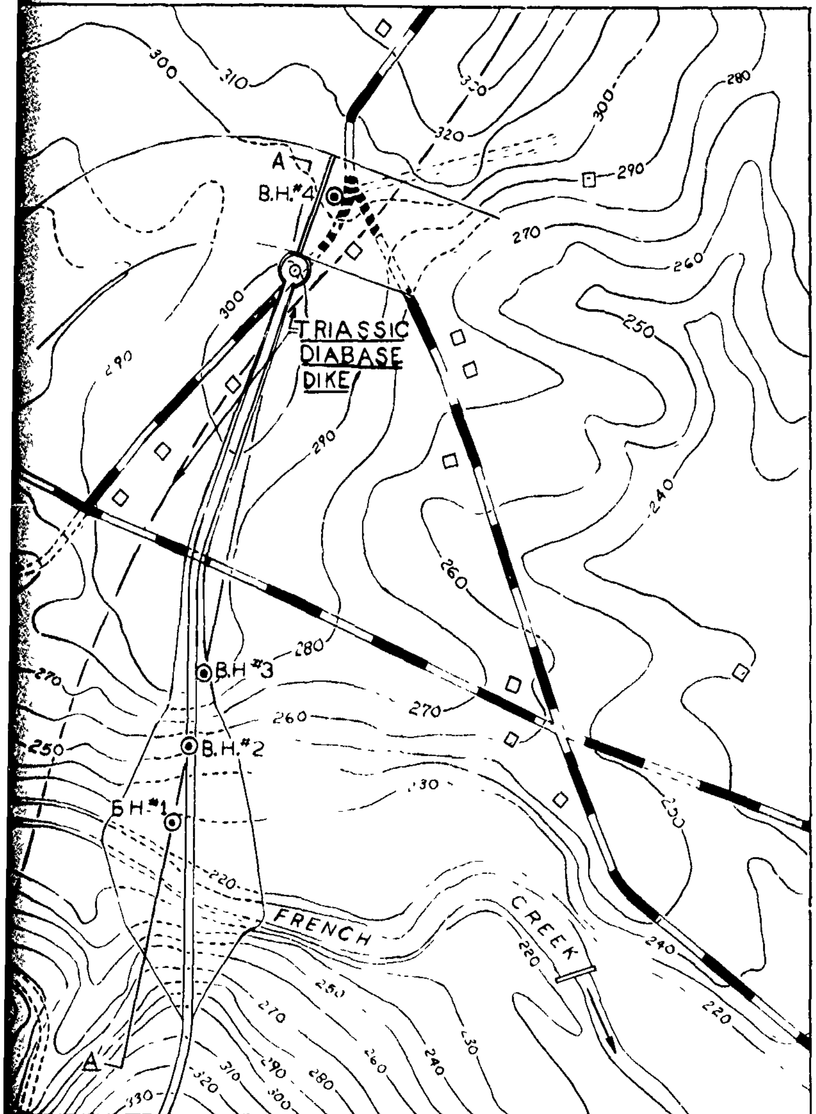
FRENCH

GEOLO

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

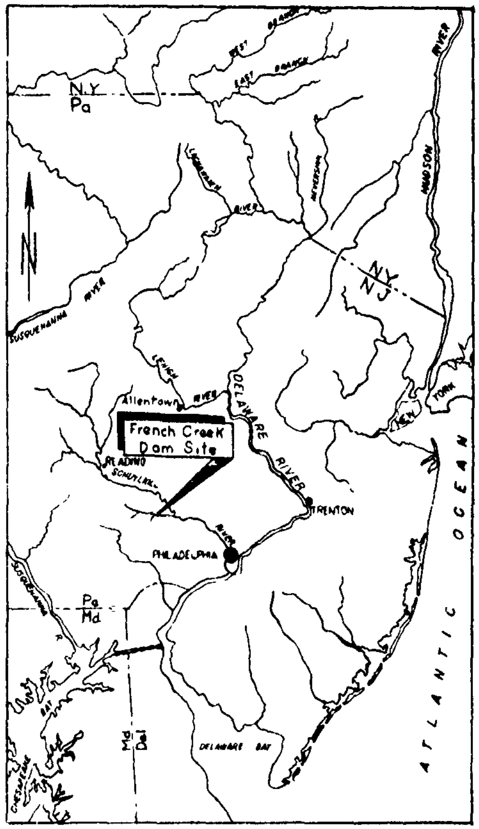
Drawer No 228

U.S. ARMY

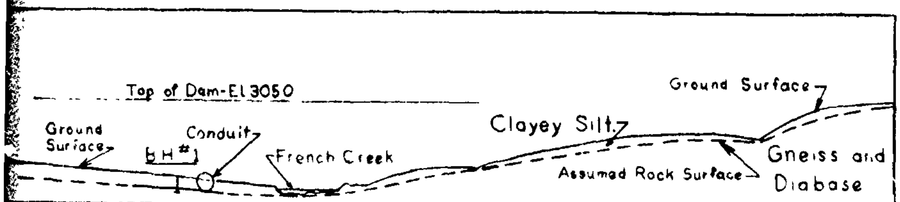


SITE MAP

0 200 500 1000 1500 FT



LOCATION MAP



REVIEW REPORT DELAWARE RIVER BASIN

FRENCH CR. PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
4 Feb 60

Drawer No 228

File No 28914

PLATE 32

36. Hackettstown Project.

a. The Hackettstown project fully developed would provide facilities for water supply, recreation and other purposes. The full development would be required some time after the year 2010. To preserve the site it is proposed that land be acquired as it becomes available and be put to immediate recreation purposes.

b. The dam would be located on the Musconetcong River about three miles upstream from Hackettstown, New Jersey. The drainage area upstream from the site is 70 square miles. Data on basic dimensions of the project at its ultimate development are as follows:

Capacity
Long term, 23,000 ac.-ft., stream bed to elevation 665

Elevations
Top of dam, 690
Spillway crest, 665
Outlet, upstream invert, 613
Stream bed at dam, 605

Area
Reservoir at elevation 665, 1,200 acres

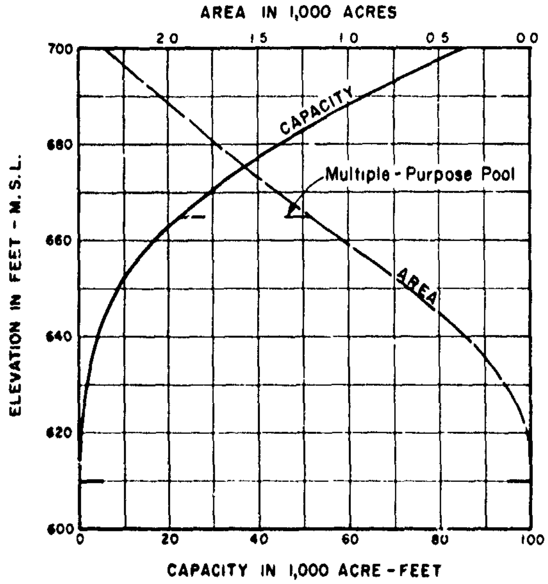
c. At the dam site the right (west) abutment is a mountain composed of pre-Cambrian gneiss with little overburden, while the valley floor and the left (east) abutment are underlain by Cambrian (Kittatinny) limestone faulted against the gneiss. Permeable glacial drift of the Wisconsin terminal moraine mantles the valley floor and the left abutment to a maximum depth of nearly 150 feet. Two bore holes at the site provided the data shown on Plate 34.

d. The dam, for which the cost estimate was made, would be a 1050-foot long embankment of rock fill with a core of impervious earth material. The top, 30 feet wide, would be at elevation 690 feet, 85 feet above the stream bed. Embankment material would be obtained from spillway excavation and from borrow pits in the valley within 1/2 mile of the site. The embankment would rest on permeable glacial drift, however, this morainal material is believed to be sufficiently tight that excessive leakage would not occur. The dam has been designed with this assumption. Should more detailed investigation, prior to construction, reveal that treatment against seepage is necessary an impervious blanket would be placed on the valley floor and sides upstream from the dam. The spillway would be located on the right abutment with a crest 85 feet long at elevation 665. The 8-foot diameter diversion and outlet tunnel would be driven through the gneiss which forms the right abutment, approximately at stream level, and would provide for diversion during construction and controlled reservoir releases thereafter.

e. The reservoir created by this dam (up to the spillway crest, elevation 665 feet) would be 60 feet deep at the dam and would extend about five miles upstream. The periphery of the reservoir at elevation 665 is extremely hard gneiss and glacial till. No weak areas, due to solution or topography, are believed to exist along the rim. It would be necessary to relocate six miles of the Delaware, Lackawanna and Western Railroad, portions of a Federal highway, several county roads, and local power and telephone lines. No commercially valuable mineral deposits are located in the reservoir area.

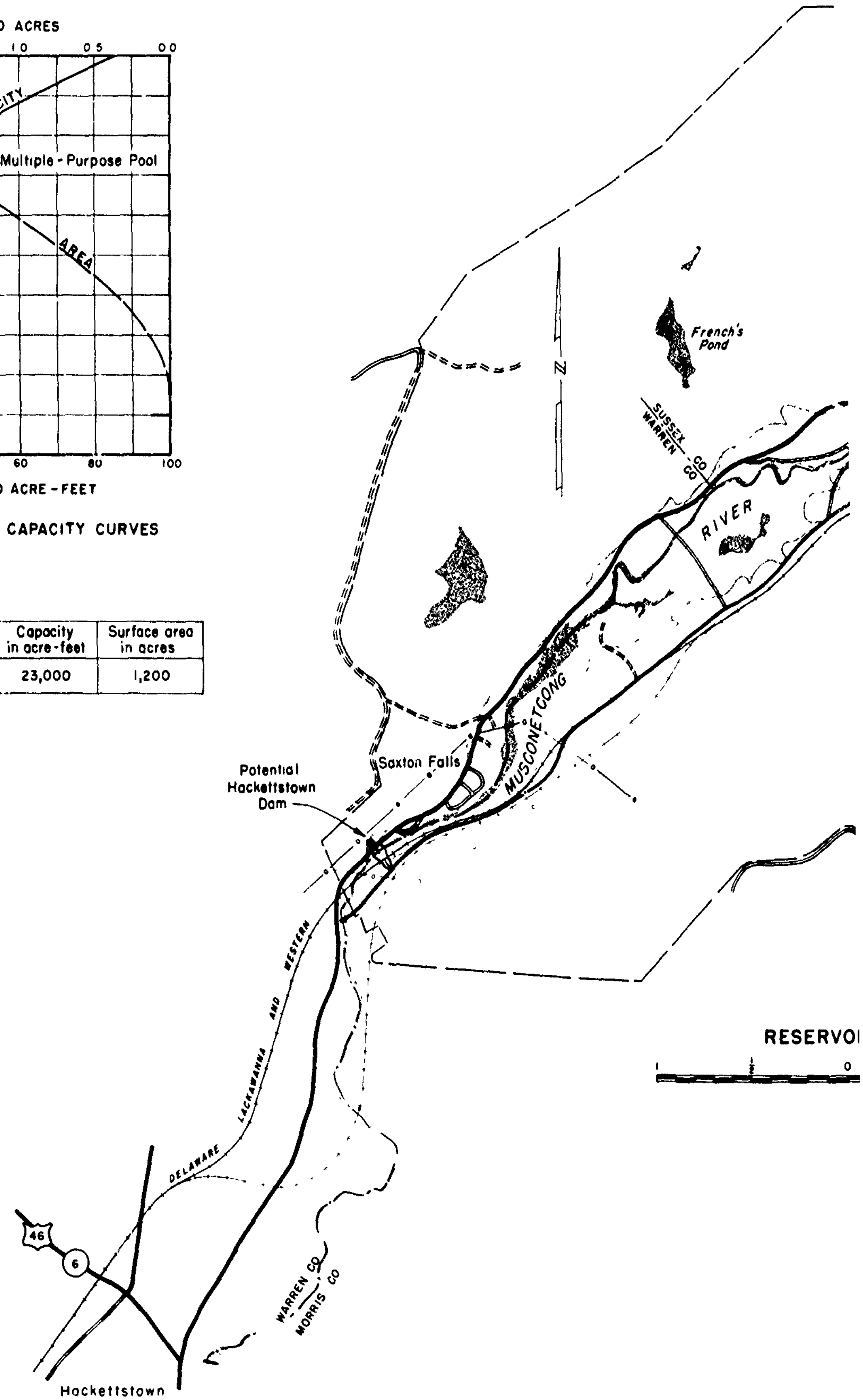
f. The estimated cost of the development, as described, is 28.0 million dollars. This estimate includes 3.5 million dollars to acquire the reservoir land area to preserve it for future use and 13.6 million dollars of specific recreation costs comprised of 5.1 million dollars for land 8.5 million dollars for recreation facilities. The remaining 10.9 million dollars is the estimated cost of the dam and appurtenant works, relocations, and reservoir clearing if the project were constructed as proposed herein.

CORPS OF ENGINEERS

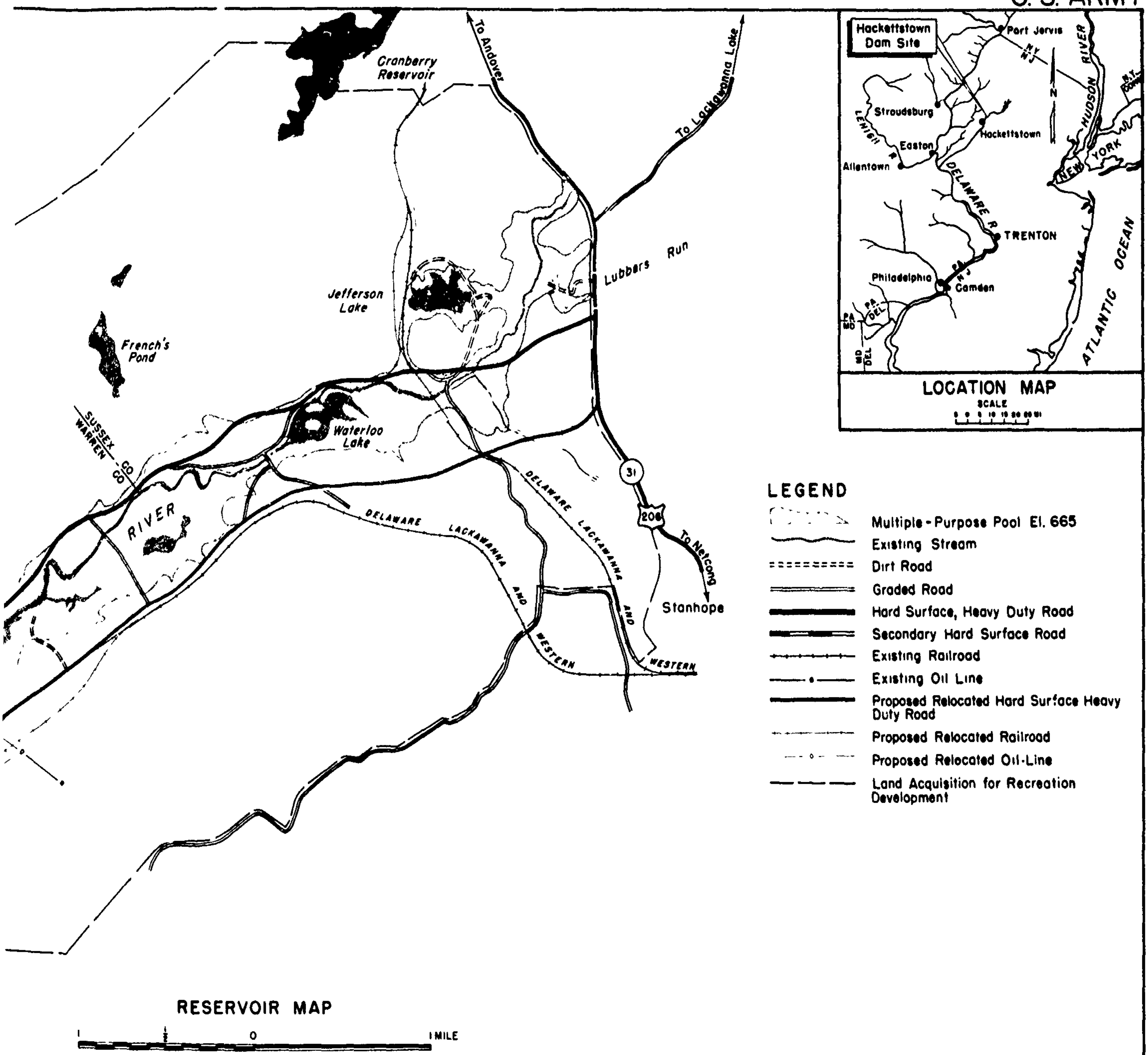


RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	665	23,000	1,200



U. S. ARMY



REVIEW REPORT DELAWARE RIVER BASIN

HACKETTSTOWN PROJECT

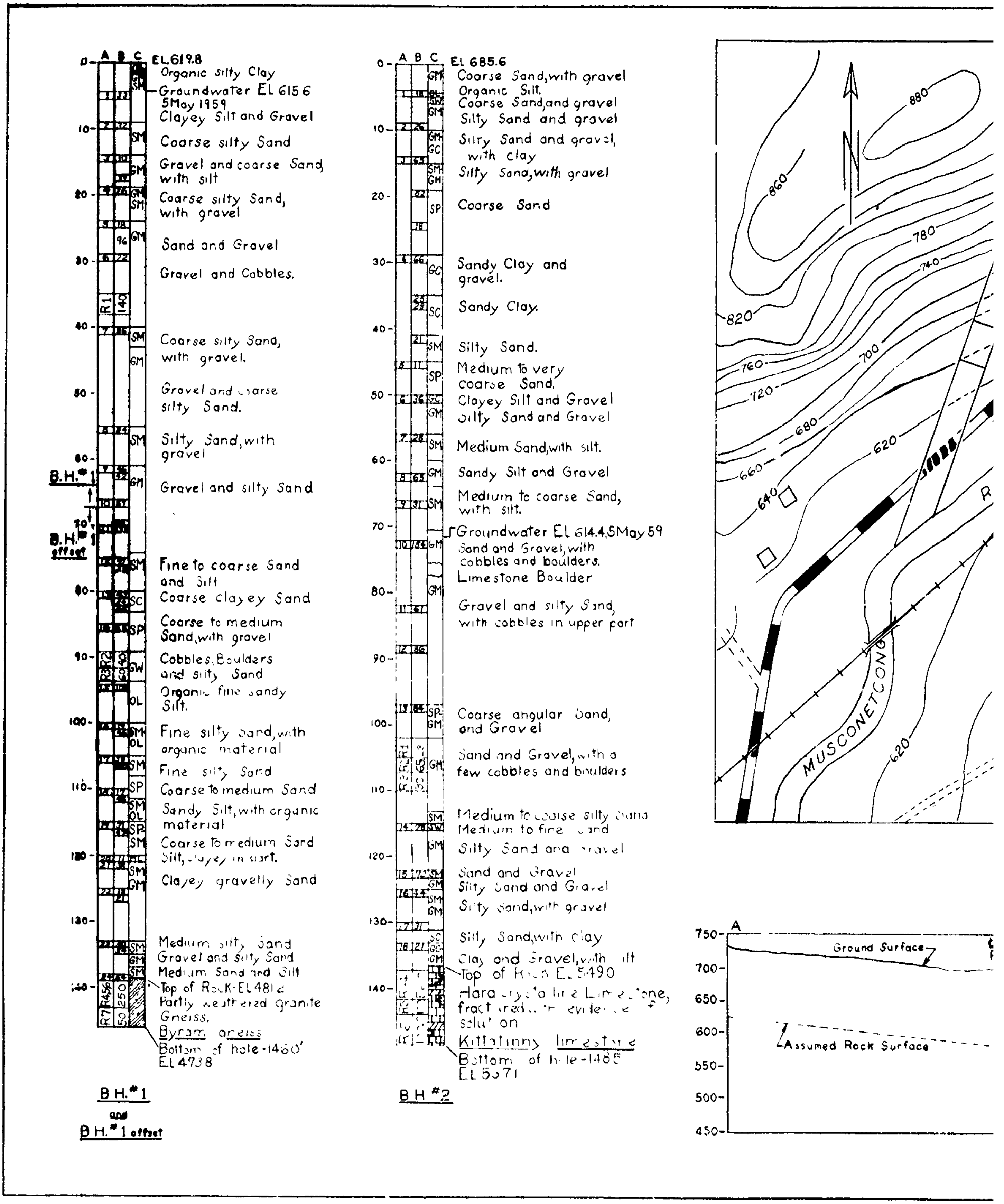
In 1 Sheet | Scale as Shown

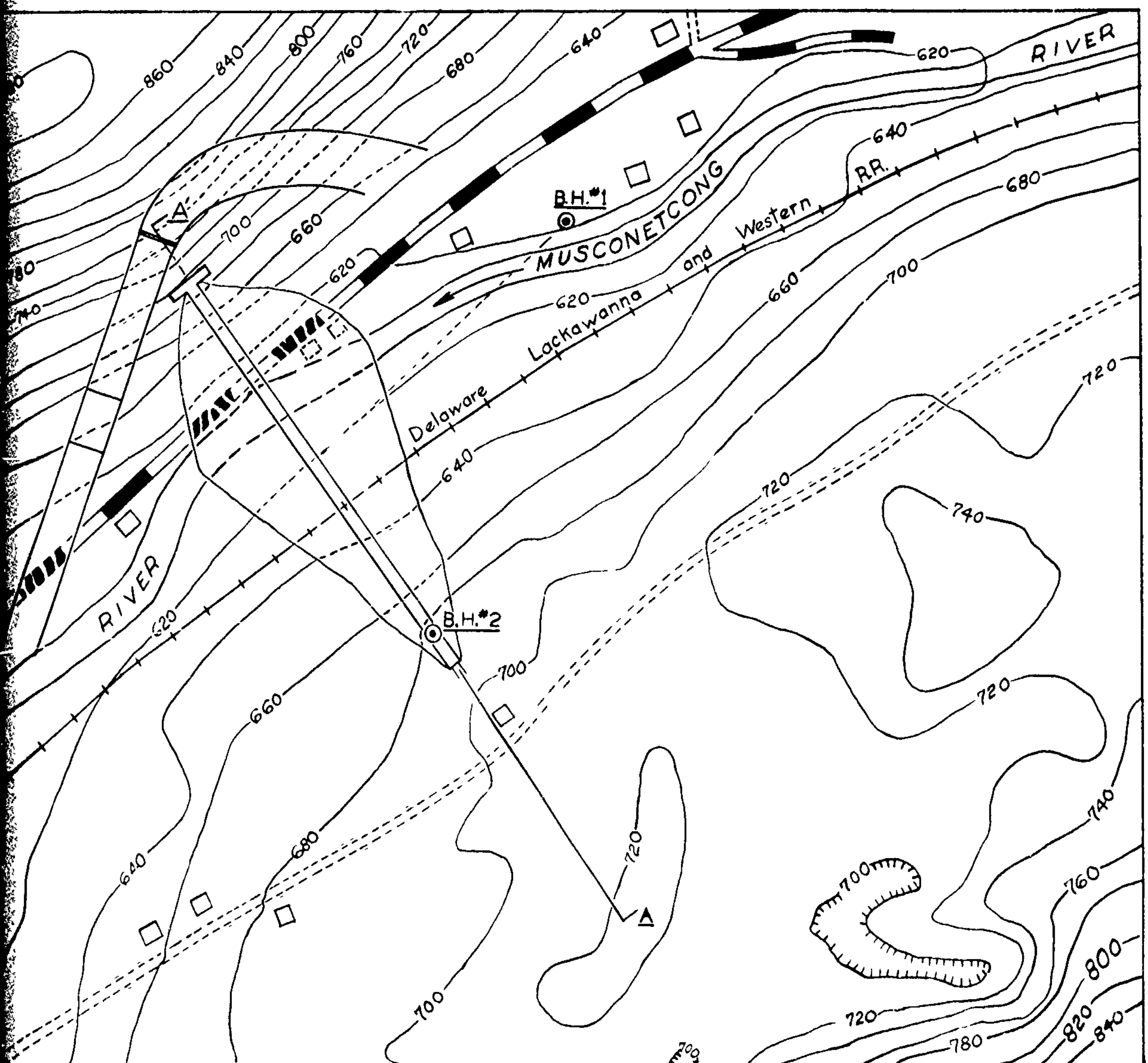
Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

Drawer No 228 | File No 29105

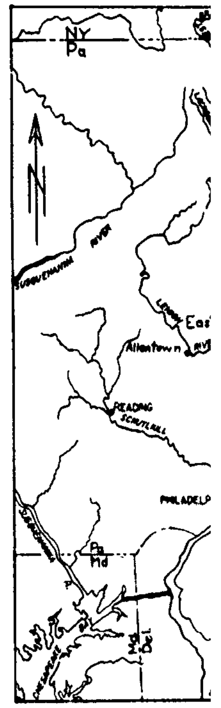
CORPS OF ENGINEERS





SITE MAP

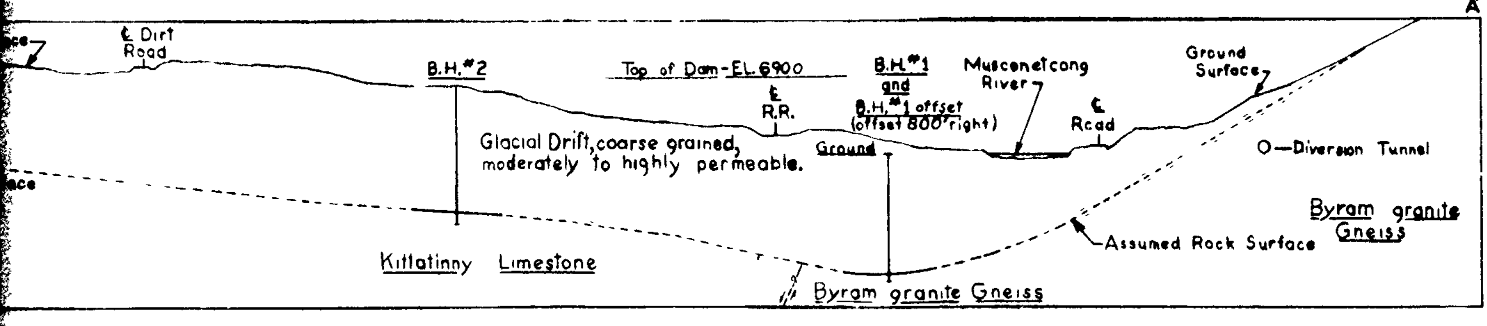
0 100 200 300 400 500 1000 FT



LOC

NOTES:

1. Descriptions of materials based on visual inspection samples
2. Numbers in column "A" indicat
3. Column "B" indicates blow c standard split spoon using percent core recovery for
4. Column "C" indicates field c using the Unified Soils Cla graphic rock symbols.
5. All elevations based on me
6. Drilling performed by Layn May 1959.
7. BH#1 lost at 66feet; BH.#
8. BH#1 is projected into the of the valley
9. Fault on profile from Ge



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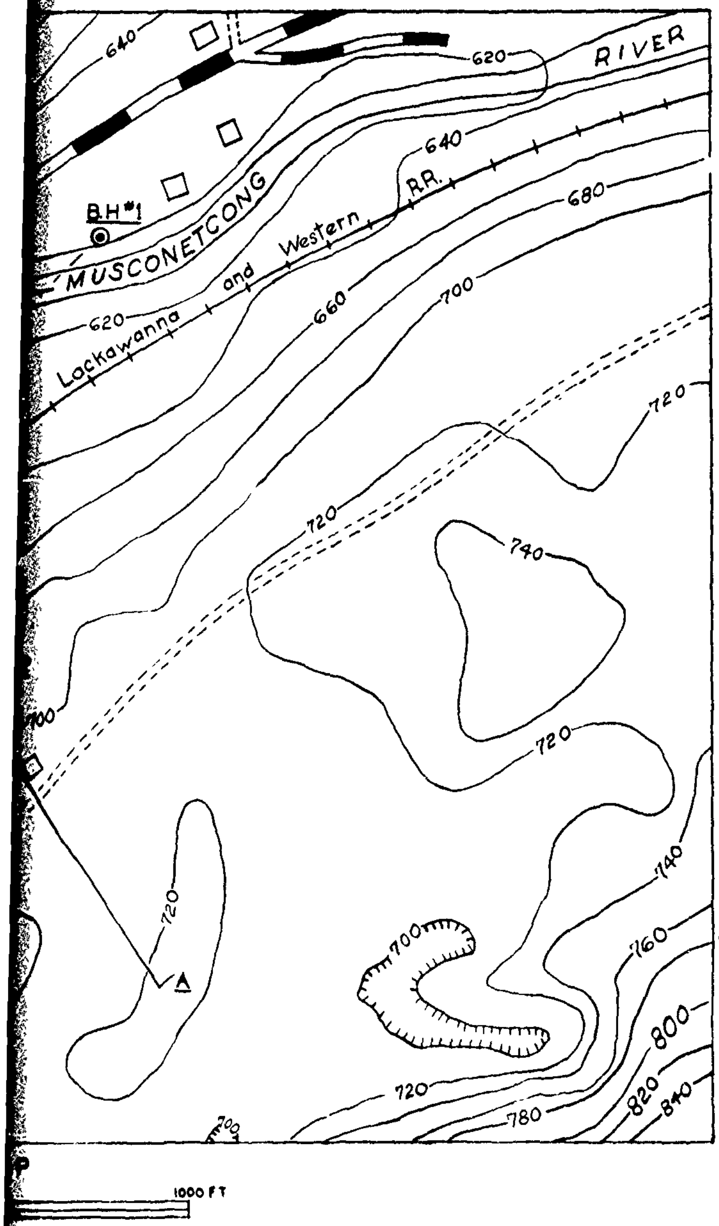
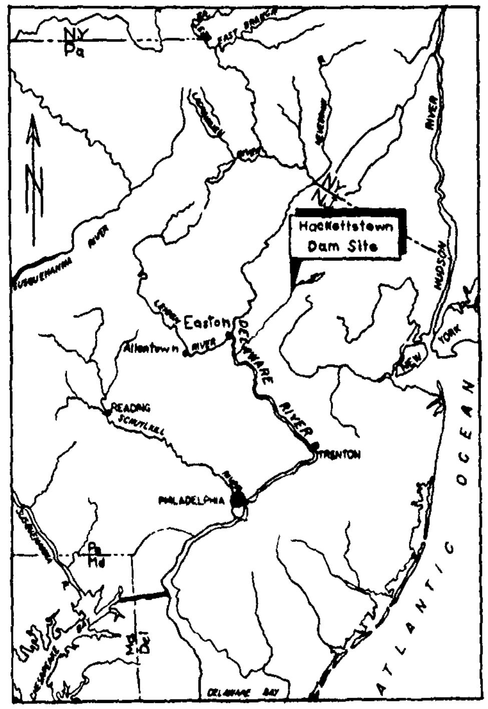
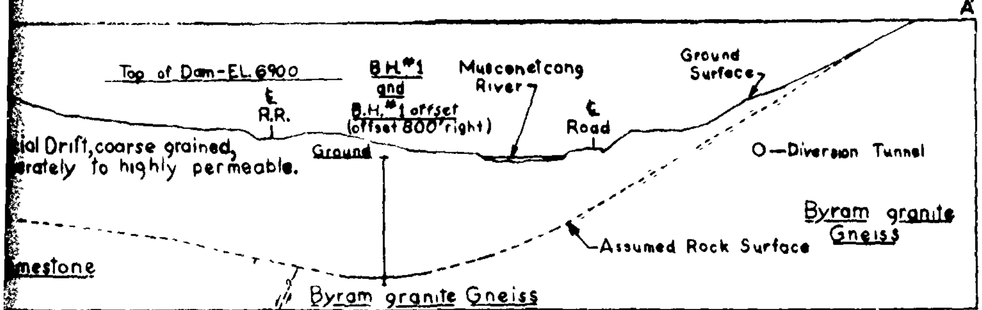




LOCATION MAP

NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of cuttings, spoon and core samples.
2. Numbers in column "A" indicates drive sample or core run number.
3. Column "B" indicates blow count for one (1) foot penetration by standard split spoon using 140 lb. weight, with a 30 inch drop, or percent core recovery for the interval shown
4. Column "C" indicates field classification of the materials using the Unified Soils Classification System symbols and graphic rock symbols.
5. All elevations based on mean sea level
6. Drilling performed by Layne, New York Co., Inc., during April, May 1959.
7. BH#1 lost at 66 feet; BH#1, offset, drilled 5 feet south.
8. BH#1 is projected into the profile parrallel to the strike of the valley
9. Fault on profile from Geologic Map of New Jersey



REVIEW REPORT DELAWARE RIVER BASIN

HACKETTSTOWN PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa.

Scales as Shown
Philadelphia District
14 Feb. 60

Drawer No 228

File No. 29087

37. <u>New Hampton Project</u>

a. The New Hampton project fully developed would provide facilities for water supply, recreation and other purposes. The full development would be required some time after the year 2010. To preserve the site, it is proposed that land be acquired as it becomes available and be put to immediate recreation purposes.

b. The dam would be located on the Musconetcong River 2.5 miles south of Washington, New Jersey. The drainage area upstream from the dam is 123 square miles. Data on basic dimensions of the project at its ultimate development are as follows:

<u>Capacity</u>
Long term, 44,000 ac.-ft., stream bed to elevation 426

<u>Elevations</u>
Top of dam, 447
Spillway crest, 426
Outlet, upstream invert, 342
Stream bed at dam, 339

<u>Area</u>
Reservoir at elevation 426, 1,850 acres

c. At the dam site the river has cut a channel in Cambrian (Kittatinny) limestone which outcrops along the right (west) abutment and above the road along the left (east) abutment upstream from the dam site. The higher slopes of the mountain on the left abutment are underlain by Cambrian quartzite and pre-Cambrian gneiss, covered by glacial drift and slope wash at the dam site. The limestone is cavernous, but is fairly well blanketed by impermeable, clayey residual soil and pre-Wisconsin glacial drift (which is 70 feet thick on the left abutment), except along the river, where outcrops occur. Three borings at this site provide the data shown on plate 36.

d. The dam, for which the cost estimate was made, would be an earth embankment, 30 feet wide at the top at elevation 447 feet (108 feet high), 2,280 feet long. Very extensive grouting would be necessary for safety and leakage control since the glacial blanket is discontinuous in the reservoir area. Material for the embankment would be obtained from spillway excavation, borrow areas along existing roads about 1/4 mile west of the Tidewater Tank Farm and from rock outcrops immediately downstream from the dam. A 220-foot wide spillway would be excavated in a saddle 2,600 feet from the right end of the embankment. Diversion during construction and controlled reservoir releases, thereafter, would be made through an 11-foot diameter conduit near stream level along the right bank of the stream

e. The reservoir created by this dam (at the spillway crest, elevation 426 feet) would be 87 feet deep at the dam and would

extend upstream about seven miles. It would be necessary to relocate the community of Changewater, an oil pipeline, some oil storage tanks, pumping plant and several miles of state and county highways. No economically valuable mineral deposits exist in the reservoir area. An abandoned small limestone quarry exists at the axis on the right abutment.

f. The estimated cost of the development, as described, is 29.6 million dollars. This estimate includes 7.3 million dollars to acquire the reservoir land area to preserve it for future use and 9.0 million of specific recreation costs comprised of 3.9 million dollars for land and 5.1 million dollars for recreation facilities. The remaining 13.3 million dollars is the estimated cost of the dam and appurtenant works, relocations, and reservoir clearing if the project were constructed as proposed herein.

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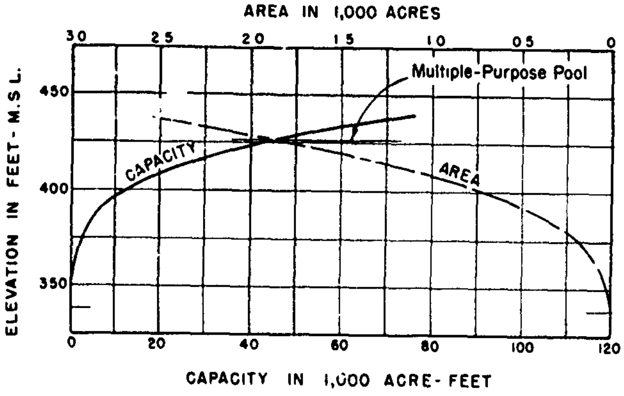
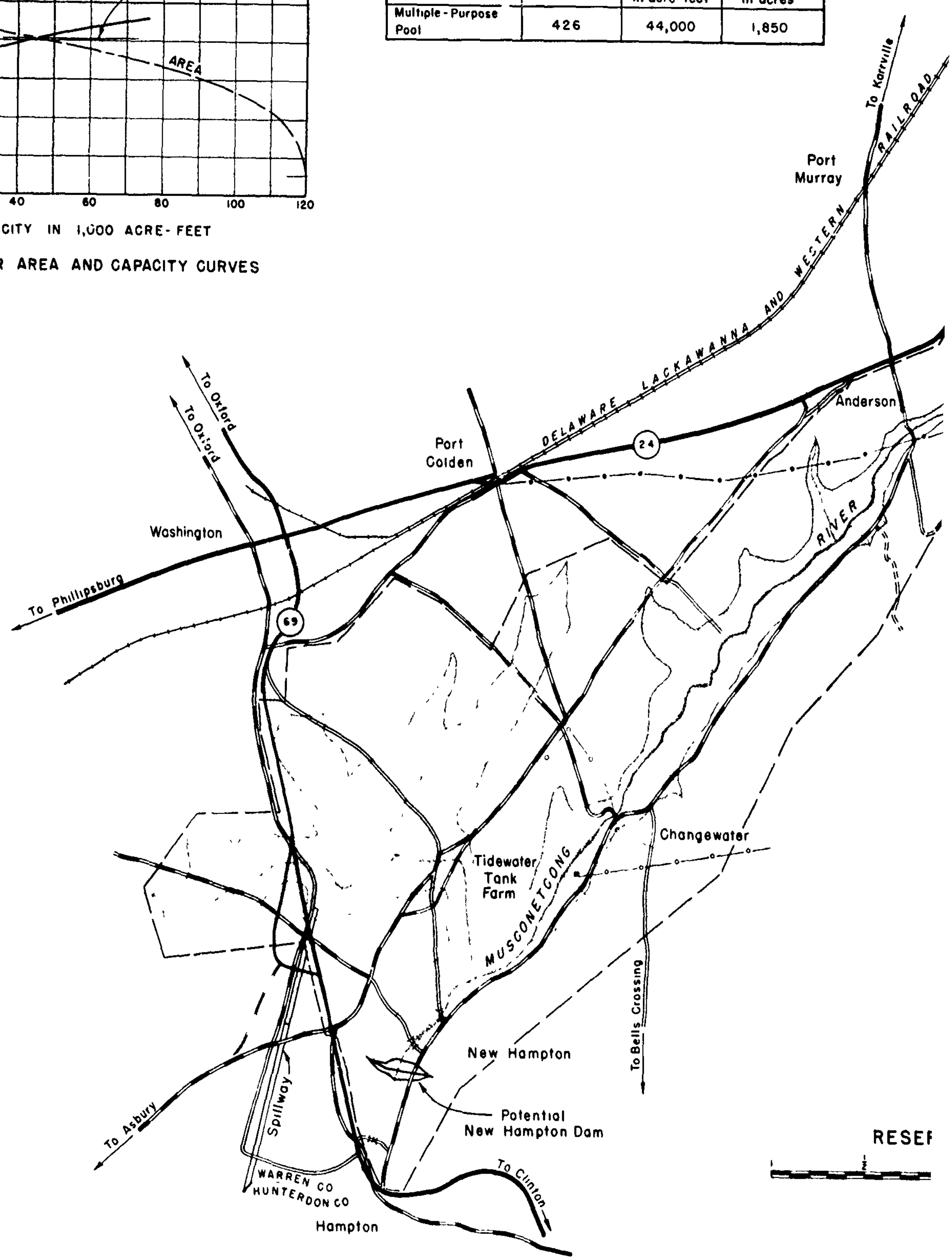


RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	426	44,000	1,850



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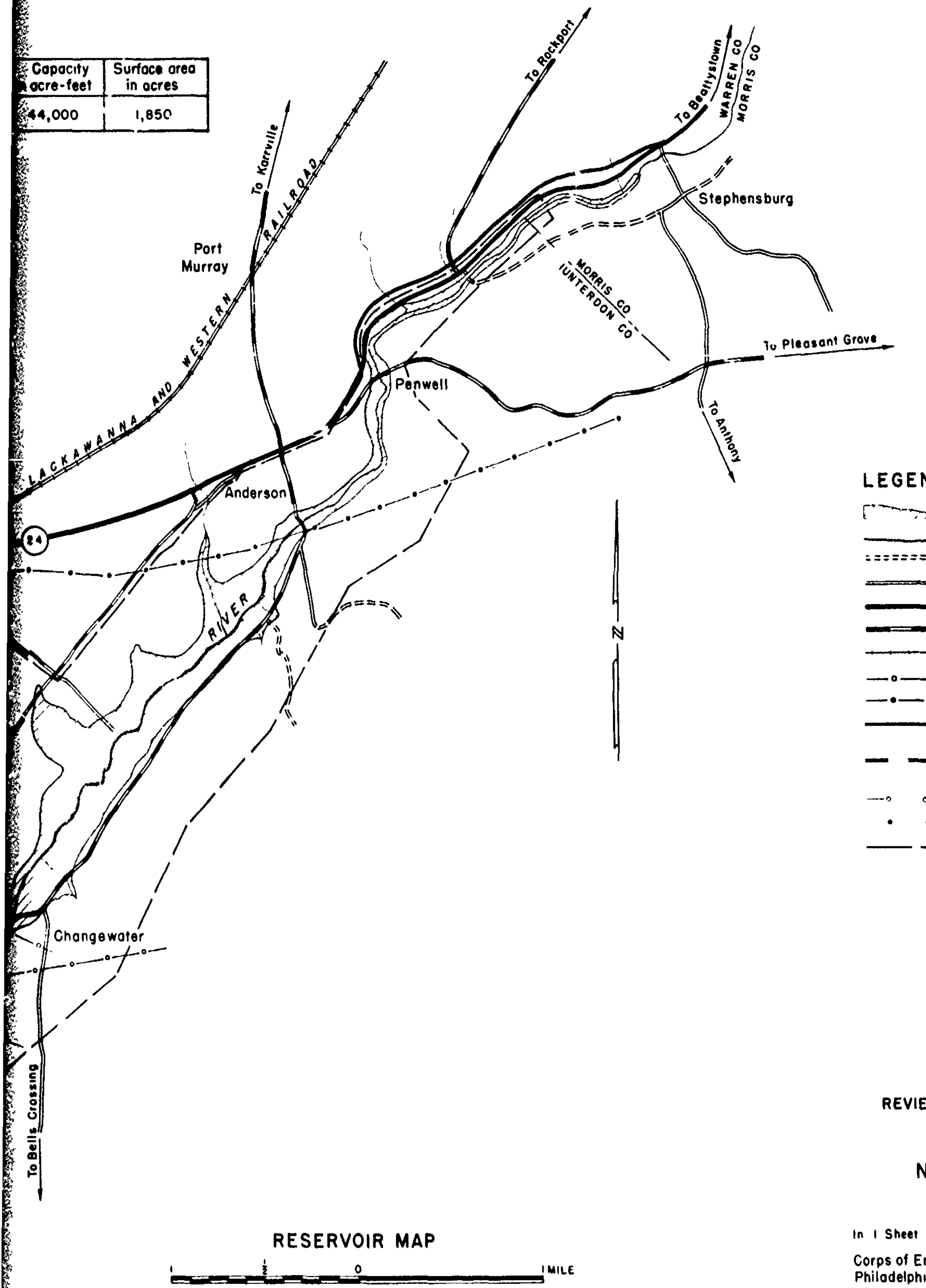
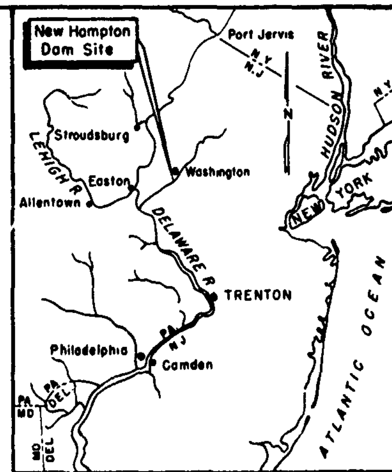
Capacity acre-feet	Surface area in acres
44,000	1,850





LOCATION MAP

SCALE

LEGEND

- Multiple-Purpose Pool El 426
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Oil Line
- Existing Telephone Line
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Oil Line
- Proposed Relocated Telephone Line
- Land Acquisition for Recreation Development

RESERVOIR MAP

1 ½ 0 1 MILE

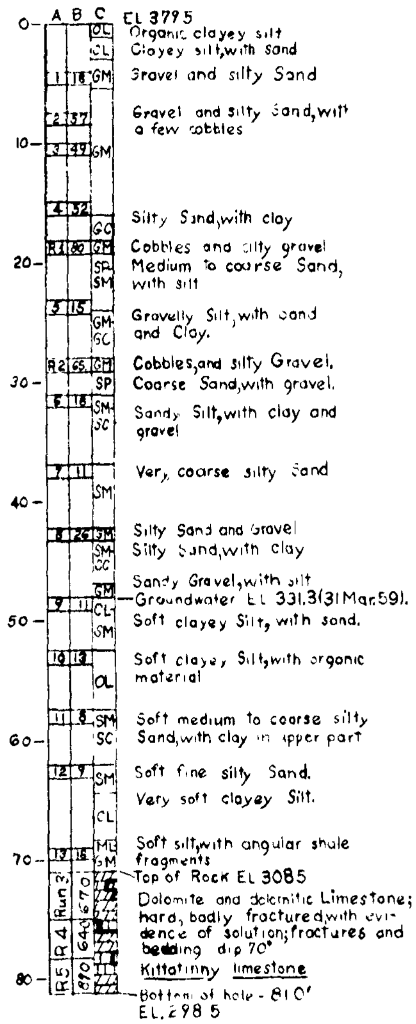
REVIEW REPORT DELAWARE RIVER BASIN

NEW HAMPTON PROJECT

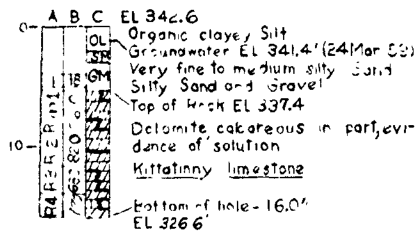
In 1 Sheet	Scale as Shown
Corps of Engineers Philadelphia, Pa	Philadelphia District June 1960
Drawer No 228	File No 29108

PLATE 35

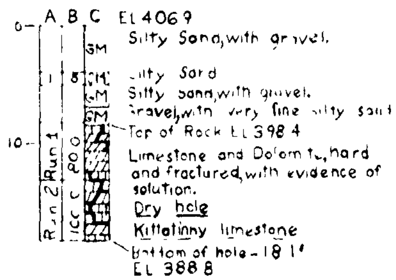
CORPS OF ENGINEERS



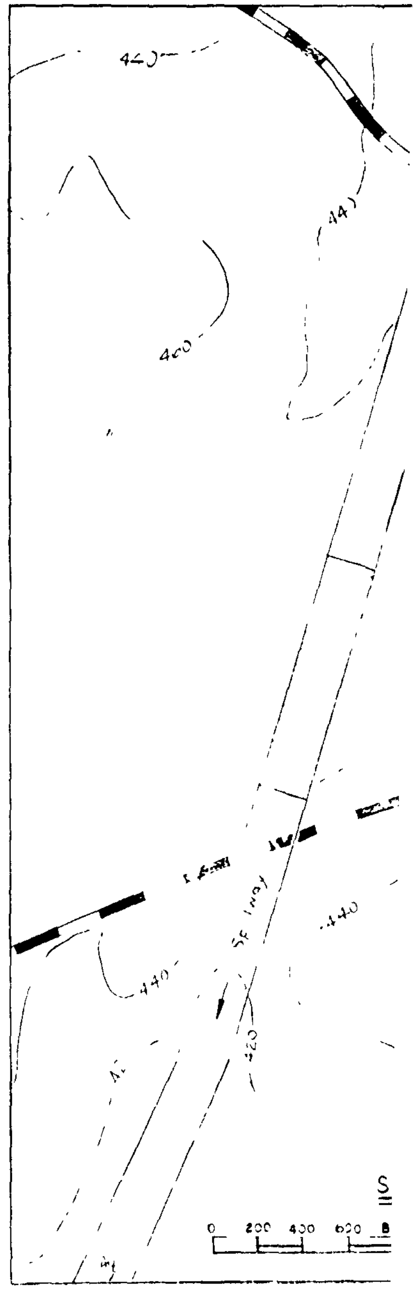
B.H.#1

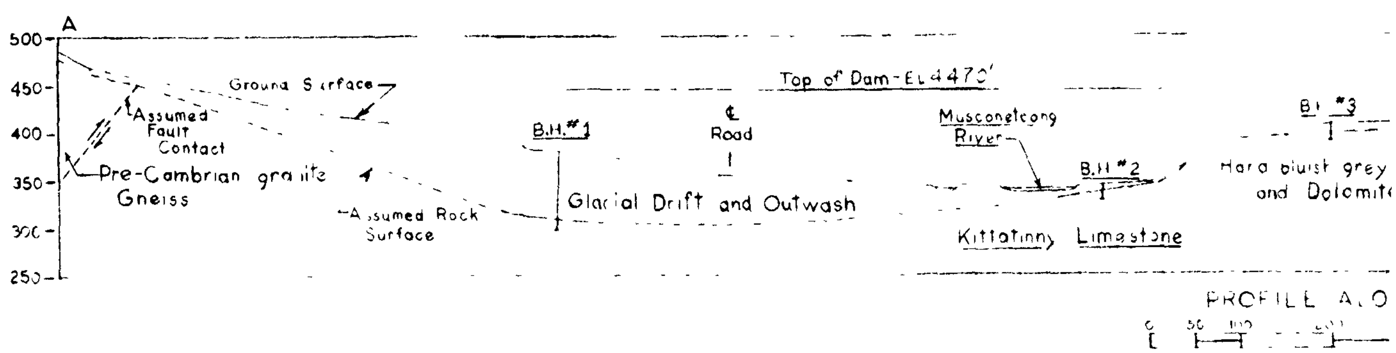


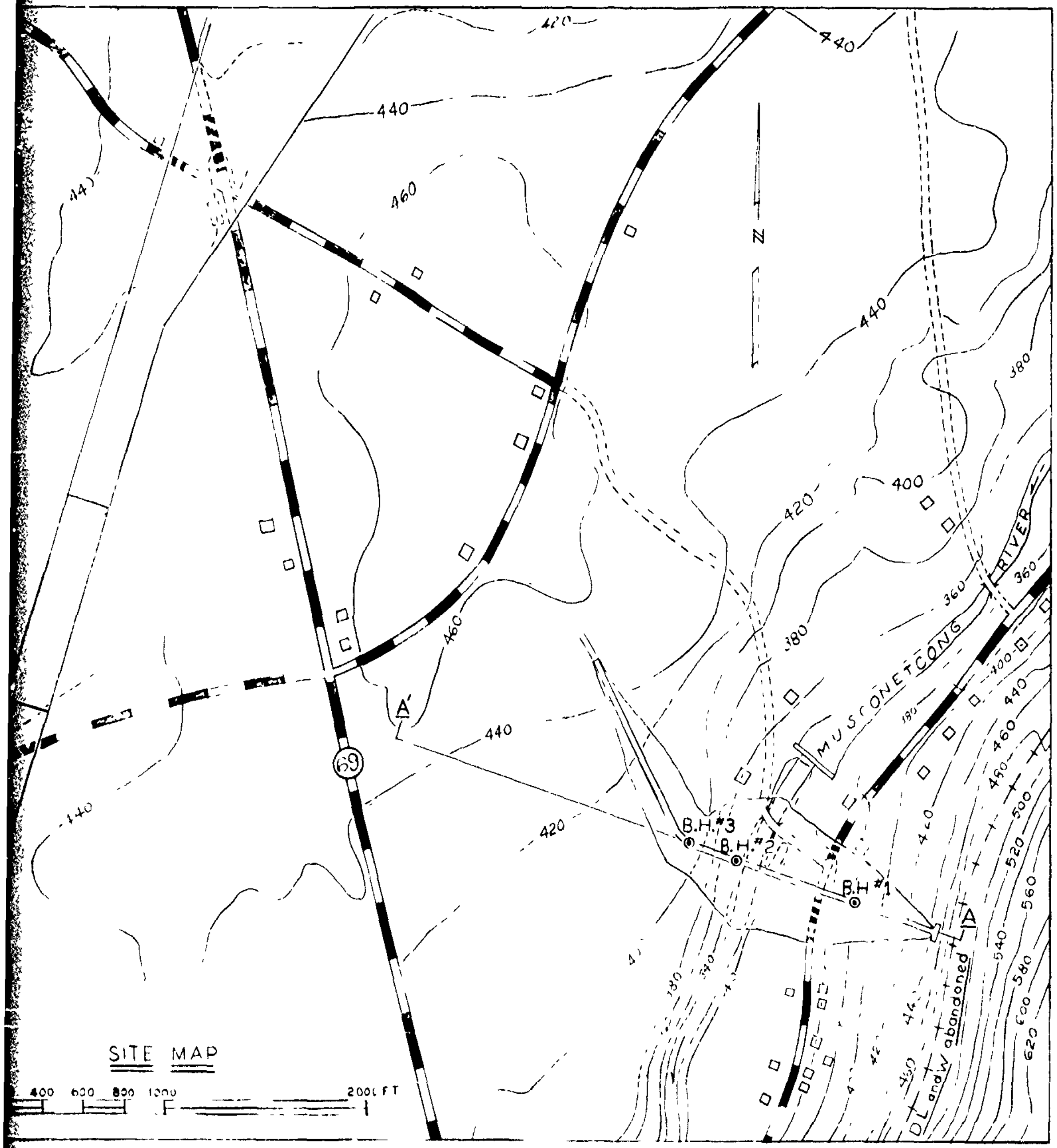
B.H.#2

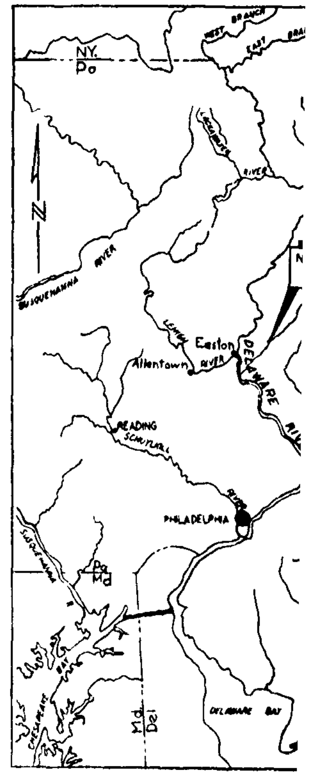


B.H.#3









LOCATION

NOTES:

1. Descriptions of materials encount
based on visual inspection of cutt
samples.
2. Numbers in column "A" indicate drive
3. Column "B" indicates blow count for
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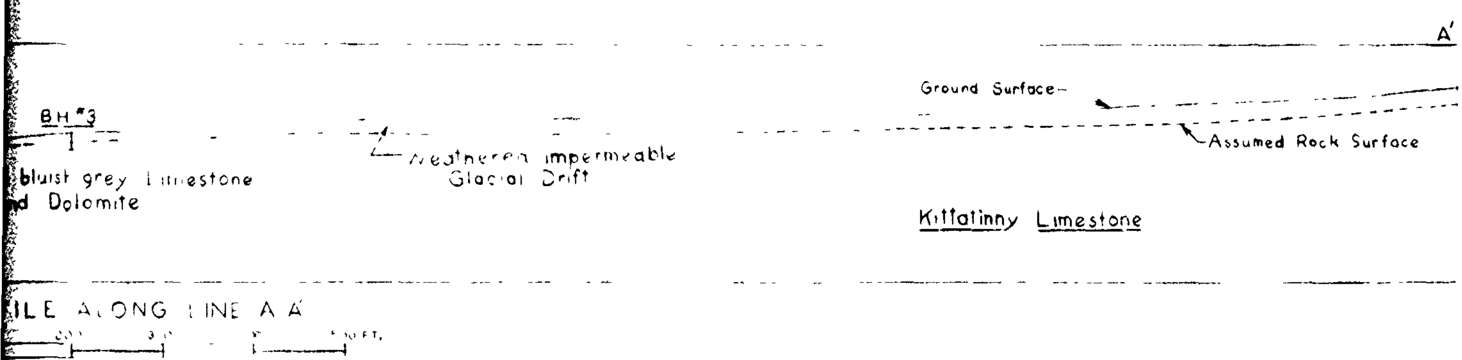
percent recovery for the interval
4. Column "C" indicates field classific
countered, using the Unified Soils
and graphic rock symbols
5. All elevations based on mean sea
6. Fault contact on geologic profile
Geologic Map by J.V. Lewis and
7. Drilling performed by Layne, Ne
March, 1959



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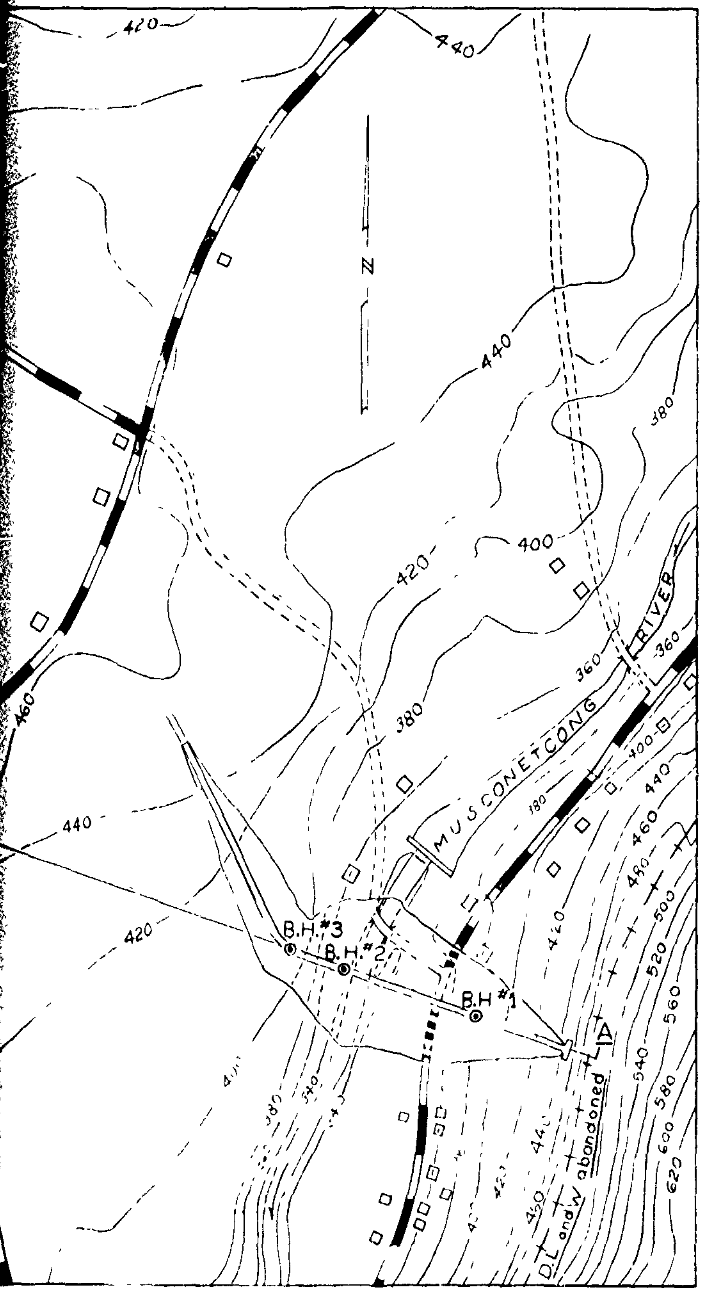
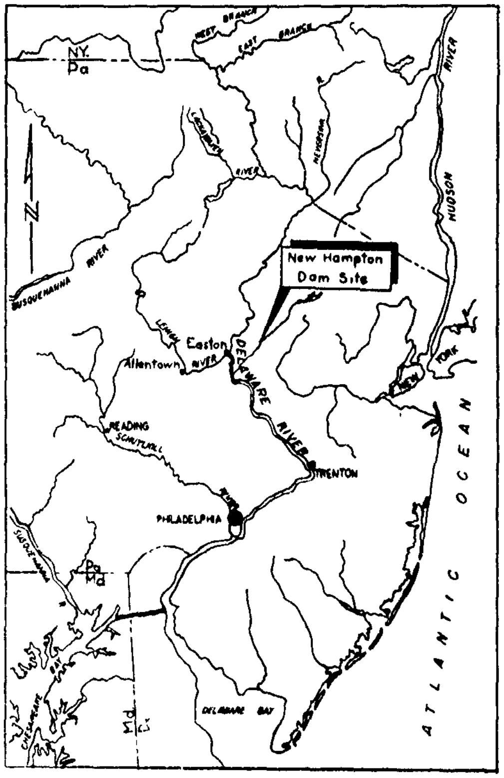
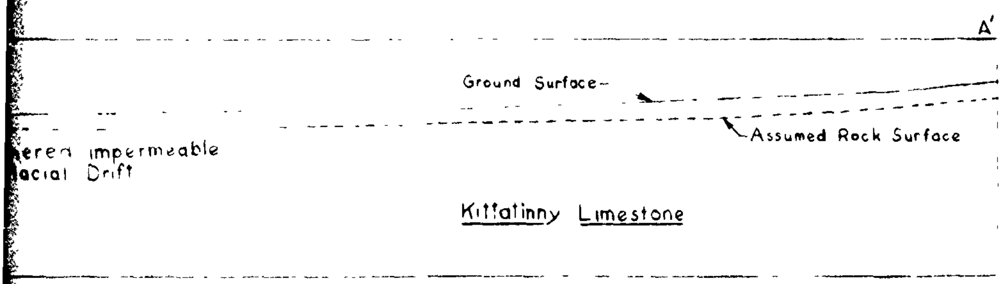




LOCATION MAP

NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of cuttings, spoon and core samples.
2. Numbers in column "A" indicate drive sample or core run numbers
3. Column "B" indicates blow count for one (1) foot penetration by standard split spoon with a 140 lb weight, 30 inch drop, or percent recovery for the interval shown.
4. Column "C" indicates field classification of the materials encountered, using the Unified Soils Classification System symbols and graphic rock symbols
5. All elevations based on mean sea level.
6. Fault contact on geologic profile from New Jersey State Geologic Map by J.V. Lewis and H.B. Kummel.
7. Drilling performed by Layne, New York Co., Inc. during March, 1959.



REVIEW REPORT DELAWARE RIVER BASIN

NEW HAMPTON PROJECT
GEOLOGIC DATA

In 1 Sheet Corps of Engineers Philadelphia, Pa.	Scales as Shown Philadelphia District 24 Feb 60
Drawer No 228	File No. 29091

38. Newtown Project

a. The Newtown project fully developed would provide facilities for water supply, recreation and other purposes. The full development would be required some time after the year 2010. To preserve the site, it is proposed that land be acquired as it becomes available and be put to immediate recreation purposes.

b. The dam would be located on Neshaminy Creek about 19 miles upstream from its confluence with the Delaware River and three miles west of Newtown, Pennsylvania. The drainage area upstream from the dam is 150 square miles. Data on basic dimensions of the project at its ultimate development are as follows:

Capacity
Long term, 62,000 ac.-ft., stream bed to elevation 176.

Elevations
Top of dam, 202
Spillway crest, 176
Outlet, upstream invert, 107
Stream bed at dam, 97

Area
Reservoir at elevation 176, 2,120 acres

c. The creek at the dam site flows along the contact of hard Triassic dark gray argillite and Triassic arkosic sandstone and red shale. Argillite, exposed in the steep left (north) abutment and in the stream bed, extends southward to a fault contact with the sandstone in the lower part of the right (south) abutment. It is not anticipated that the fault would cause reservoir leakage. Residual soils on the argillite are silty clays, while the deeper soils over the sandstone are sandy clays. Alluvial clayey silts cover the flood plain. Eight auger borings for a borrow investigation were made in the area and with the geologic investigation provided data shown on plate 38. No borings to determine location or type of bedrock were considered necessary because of the numerous rock outcrops in the area.

d. The dam, for which the cost estimate was made, would be an earth embankment up to elevation 202 with a top 30 feet wide by 2,660 feet long. Embankment material would come from excavation in the spillway channel, and from borrow areas within 1/2 mile south of the dam along the existing road. The 200-foot wide spillway would cross the right abutment above the dam. Diversion during construction, and controlled reservoir releases thereafter, would flow through an 18-foot diameter conduit at stream bed elevation on the side of the valley floor.

e. The reservoir created by this dam (up to the spillway crest, elevation 176 feet) would be 79 feet deep at the dam and would extend about nine miles upstream. It would be necessary to relocate two communities, portions of two state highways and several miles of county roads. A power line would require reinforcing where it crosses the upper end of the reservoir. Four large capacity quarries, three of them new, are quarrying argillite for aggregate in, or near the central portion of the reservoir. The capacities of the crushing plants range from 100 to 800 tons per hour, and the sizes of the primary crushers range from 18" x 30" to 42" x 48". No other commercial mineral deposits exist in the reservoir area.

f. The estimated cost of the development, as described, is 46.4 million dollars. This estimate includes 9.3 million dollars to acquire the reservoir area to preserve it for future use and 18.5 million dollars of specific recreation costs comprised of 12.1 million dollars for land and 6.4 million dollars for recreation facilities. The remaining 18.6 million dollars is the estimated cost of the dam and appurtenant works, relocations, and reservoir clearing if the project were constructed as proposed herein.

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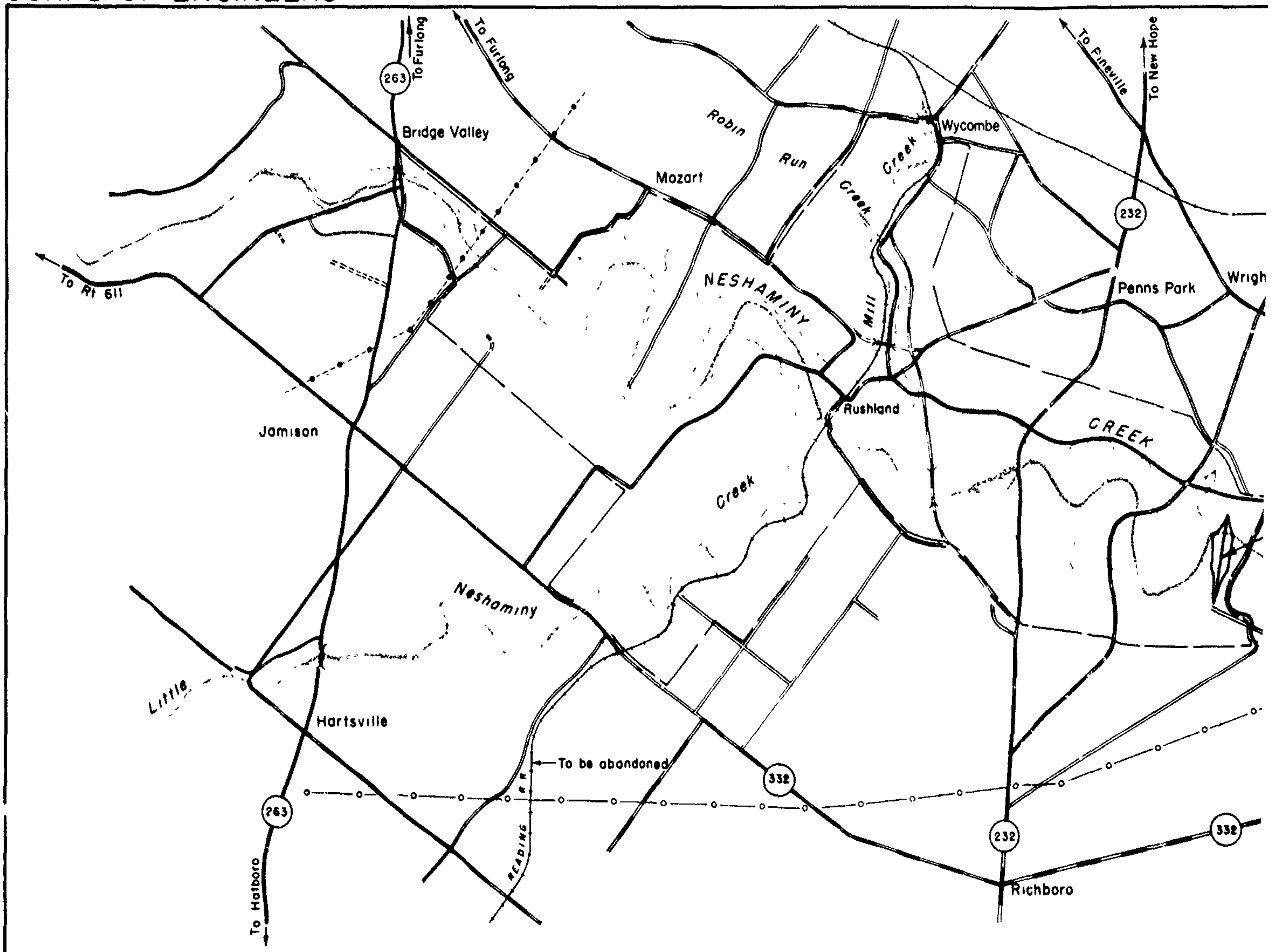
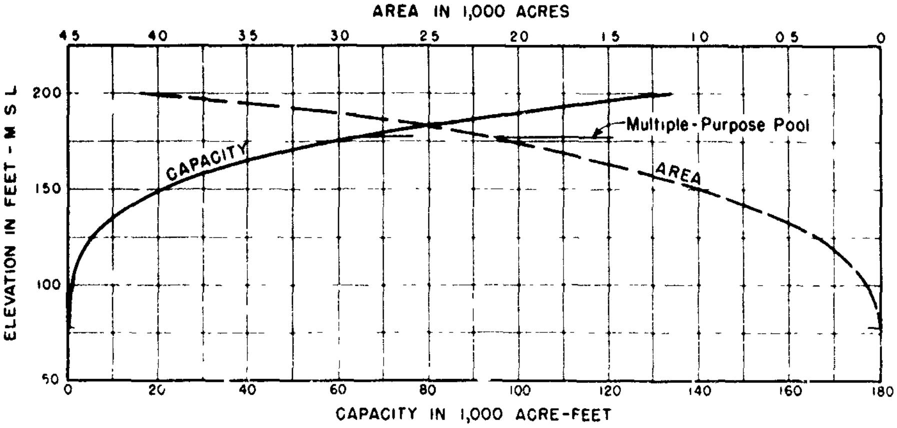


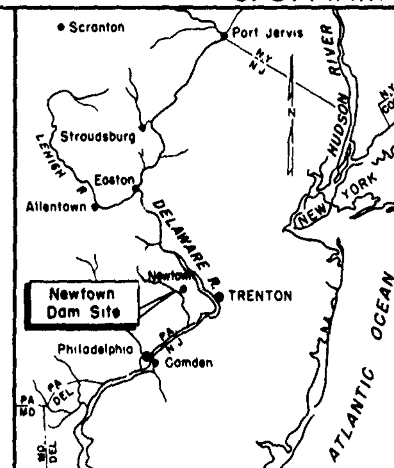
RESERVOIR MAP

1 MILE



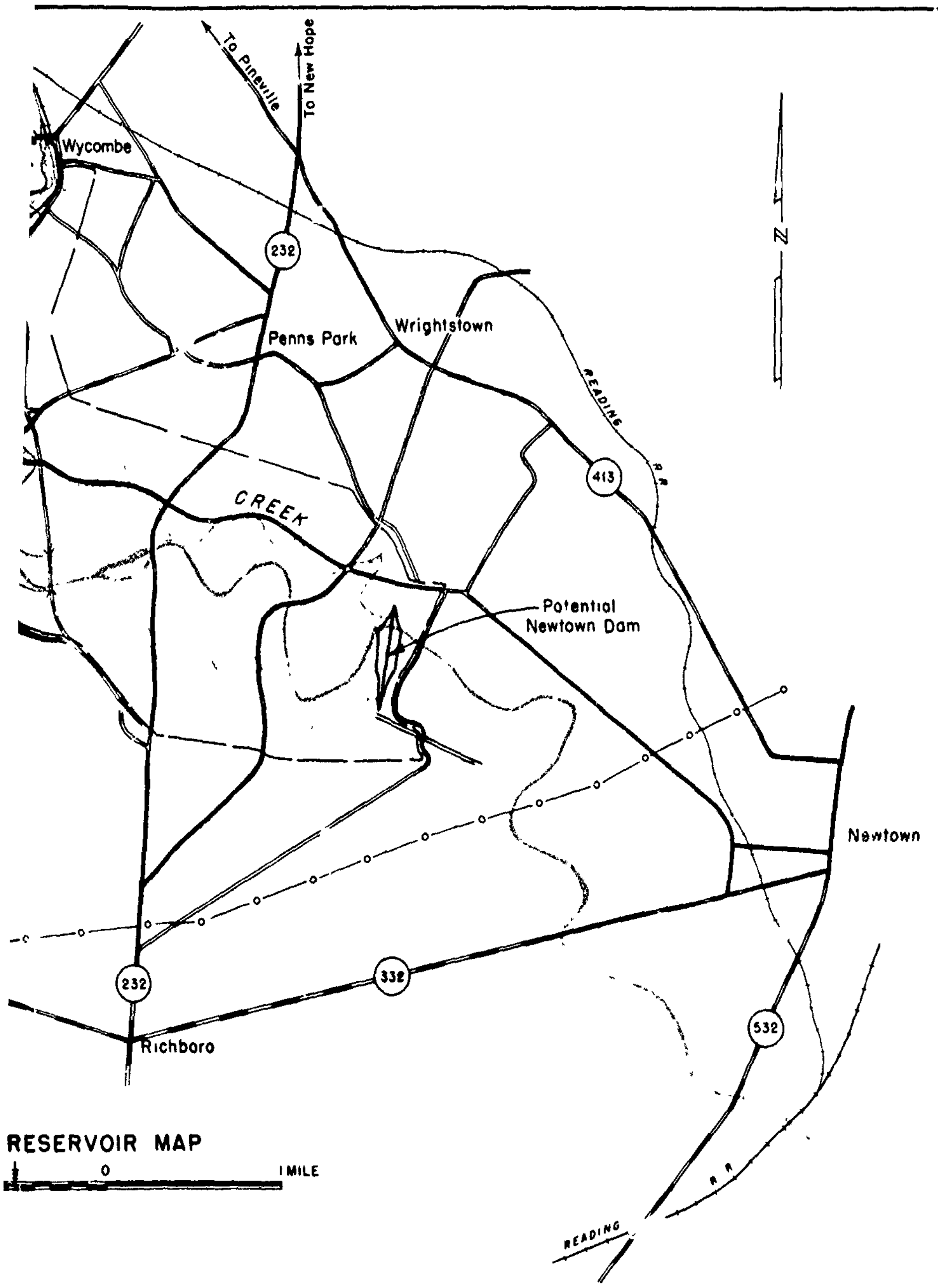
RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	ir
Multiple - Purpose Pool	176	



LOCATION MAP

SCALE



RESERVOIR MAP

0 1 MILE

LEGEND

- Multiple-Purpose Pool El. 176
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Existing Gas Pipe Line
- Proposed Relocated Graded Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Railroad
- Proposed Relocated Power Line
- Land Acquisition for Recreation Development

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple - Purpose Pool	176	62,000	2,120

REVIEW REPORT DELAWARE RIVER BASIN

NEWTOWN PROJECT

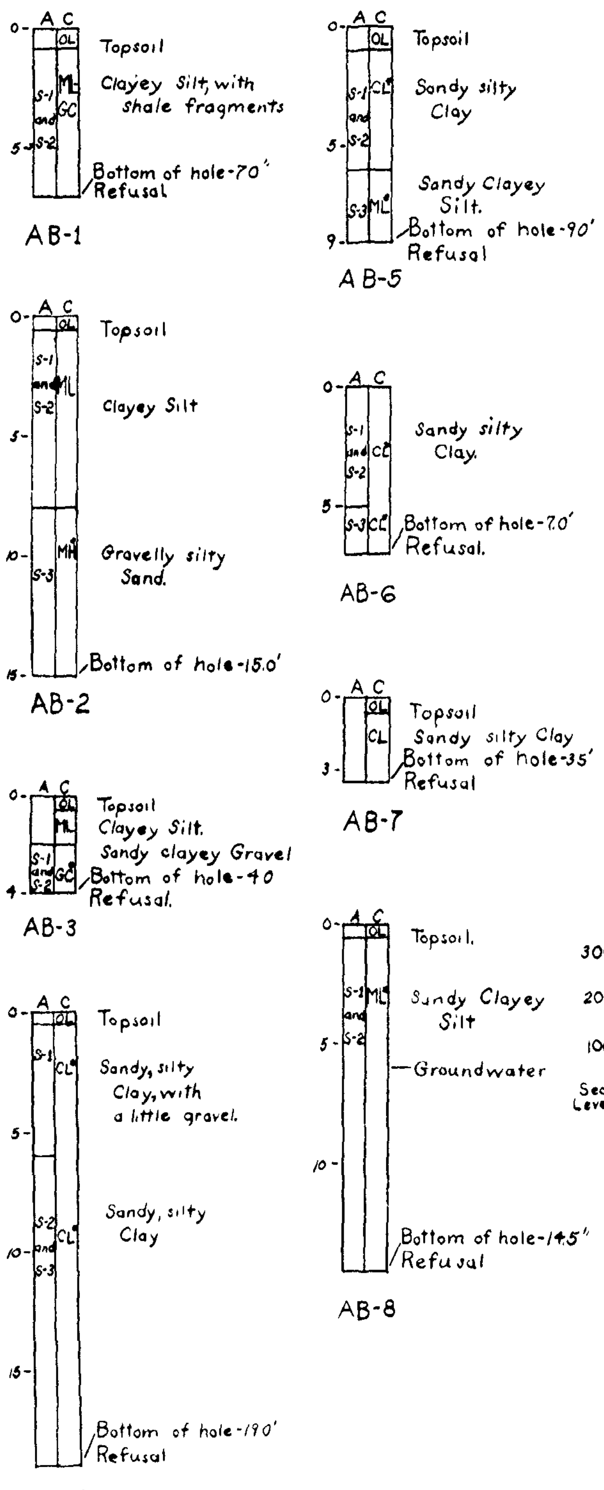
In 1 Sheet | Scale as Shown

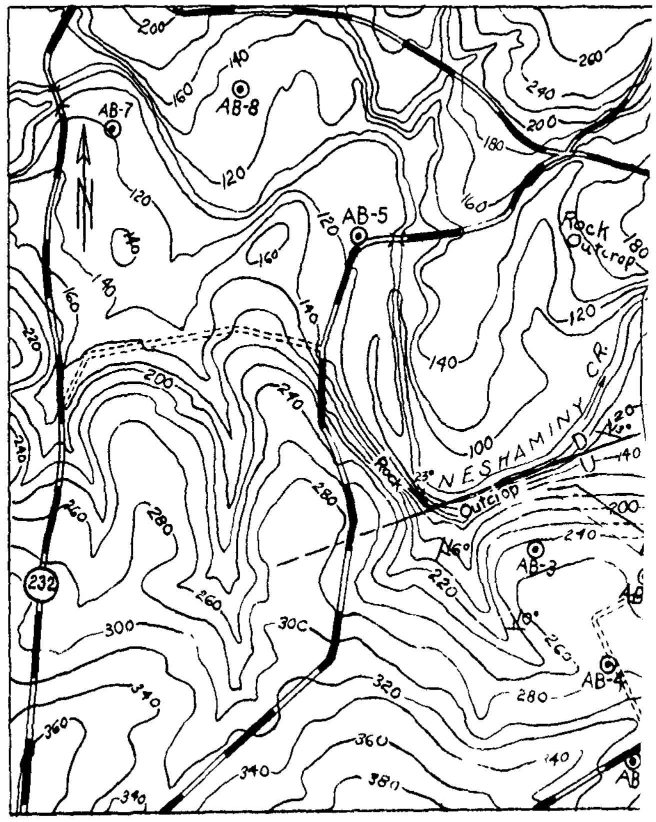
Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

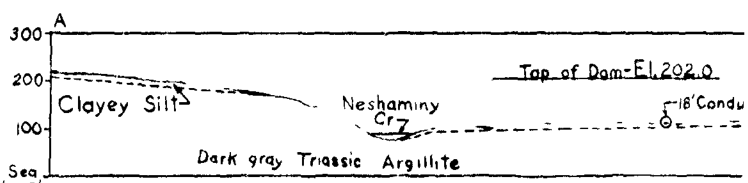
Drawer No 228 | File No 29113

CORPS OF ENGINEERS





SITE MAP



PROI

NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of spoon samples.
2. Column "A" refers to the sample number
3. Column "B" refers to the number of blows a 140 lb hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered.
4. Column "C" is a field classification of the materials encountered, using the Unified Soils Classification System symbols, except where noted by an asterisk (*) which denotes a lab classification
5. — shows direction of strike of bedrock and direction and magnitude of dip in degrees
6. Borings have not been surveyed, locations are only approximate.
7. of Bu Penns Bulleti
8. U-rep D-rep
9. No bo of roc
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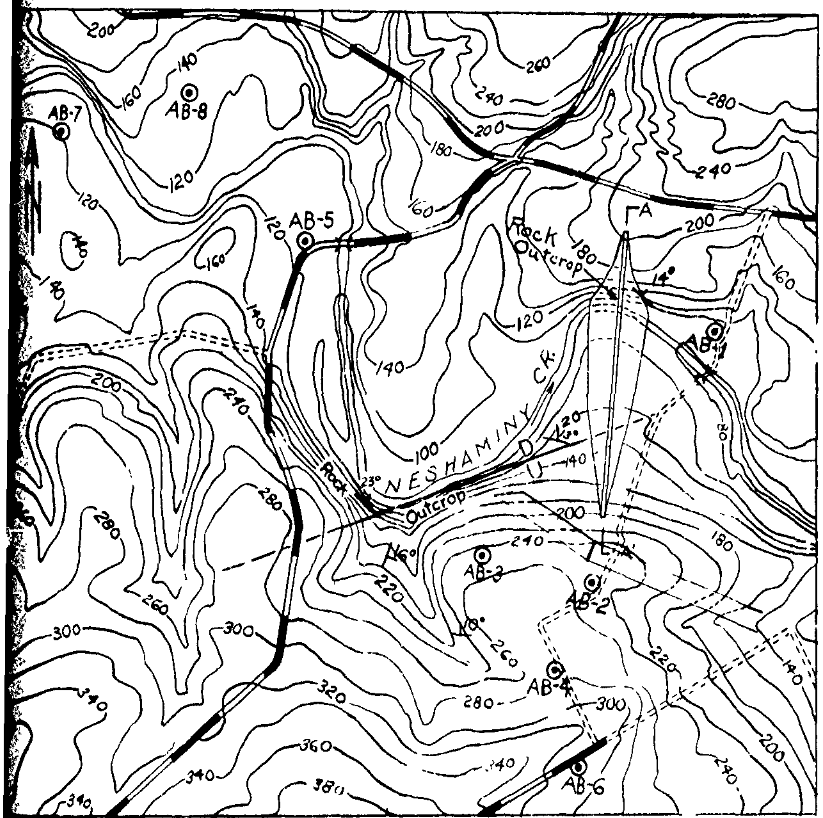
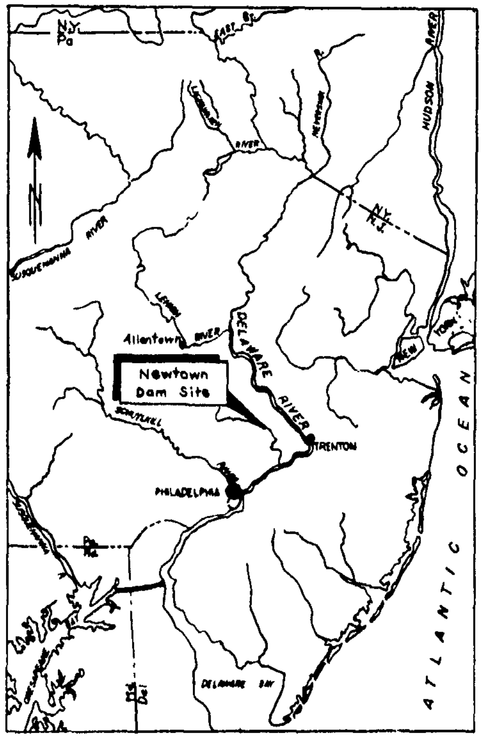
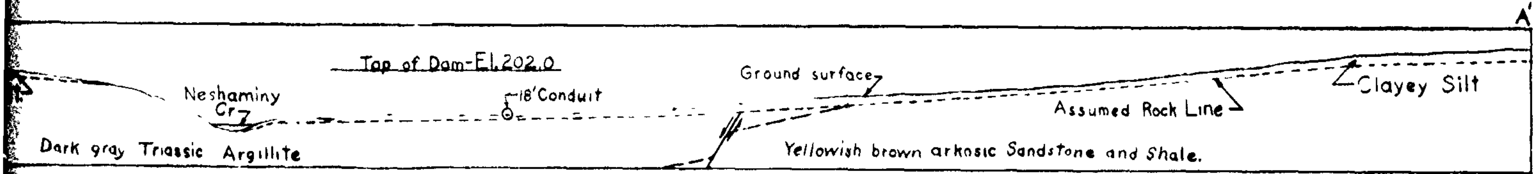


SITE MAP

0 1000 2000 3000 4000 FEET



LOCATION MAP



PROFILE ALONG LINE A-A'

0 200 400 600 800 1000 FT.

...tions of materials encountered in borings are based ...l inspection of spoon samples.

..."A" refers to the sample number

..."B" refers to the number of blows a 140 lb hammer ...g 30 inches required to push the sampling spoon ... foot into the materials encountered.

..."C" is a field classification of the materials encountered, ...the Unified Soil Classification System symbols, ex...where noted by an asterisk (*) which denotes a lab ...ication

...hows direction of strike of bedrock and direction and ...tude of dip in degrees

...s have not been surveyed, locations are only ...ximate.

7. U/D shows fault from Ground Water Resources of Bucks County, Pennsylvania, by D W Greenman, Pennsylvania Topographic and Geologic Survey, Bulletin W11, Plate 1, 1955

8. U-represents the upthrown side of fault and D-represents downthrown side of fault.

9. No borings made along axis of dam because of rock outcrop and thin cover of overburden

10. Borrow Investigations performed by Corps of Engineers, Baltimore Dist, April, 1959

REVIEW REPORT DELAWARE RIVER BASIN

NEWTOWN PROJECT
GEOLOGIC DATA
and
BORROW INVESTIGATIONS

In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
14 Jan. 60

Drawer No 228

File No 29092

39. Paulina Project

a. The Paulina project fully developed would provide facilities for water supply, recreation and other purposes. The full development would be required some time after the year 2010. To preserve the site, it is proposed that land be acquired as it becomes available and be put to immediate recreation purposes.

b. The dam would be located on Paulins Kill about 11.25 miles above the mouth on the Delaware River and 1.5 miles east of Blairstown, New Jersey. The drainage area upstream from the dam site is 122 square miles. Data on basic dimensions of the project at its ultimate development are as follows:

Capacity

Long term, 55,000 ac.-ft., stream bed to elevation 465.

Elevations

Top of dam, 487	Outlet, upstream invert, 354
Spillway crest, 465	Stream bed at dam, 350

Area

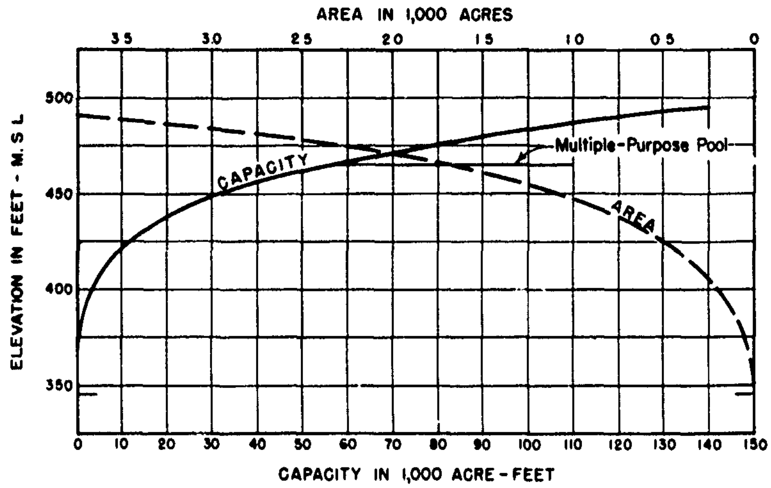
Reservoir at elevation 465, 1,650 acres

c. At the dam site the stream has cut through a narrow ridge of hard, dark gray Ordovician slate, which is exposed in the stream bed and both abutments. The narrow flood plain between the stream and the railroad, which runs along the stream, has very little overburden. A normal fault of large displacement crosses the stream a short distance below the dam site and three miles upstream. Slate is on the east side of this fault and Kittatinny limestone on the west side. Reservoir leakage is unlikely because of the location of the limestone. Overburden material is glacial drift and silty clay, usually having low permeability and spotty distribution. The limestone is cavernous, but sinkholes are difficult to separate from glacial "kettle holes." No borings to determine location and type of bedrock were considered necessary because of the numerous rock outcrops in the area. However, geologic data, based on field observations, are shown on plate 40.

d. The dam, for which the cost estimate was made, would be an earth embankment up to the 30-foot wide top at elevation 487 (137 feet high), 860 feet long. Material for this embankment would come from spillway excavation and borrow areas in the valley near the dam. A 200-foot wide unlined spillway would cross the ridge which forms the left end of the embankment. Stream diversion during construction, and controlled reservoir releases thereafter, would flow through a 10-foot diameter conduit on the left bank of the stream.

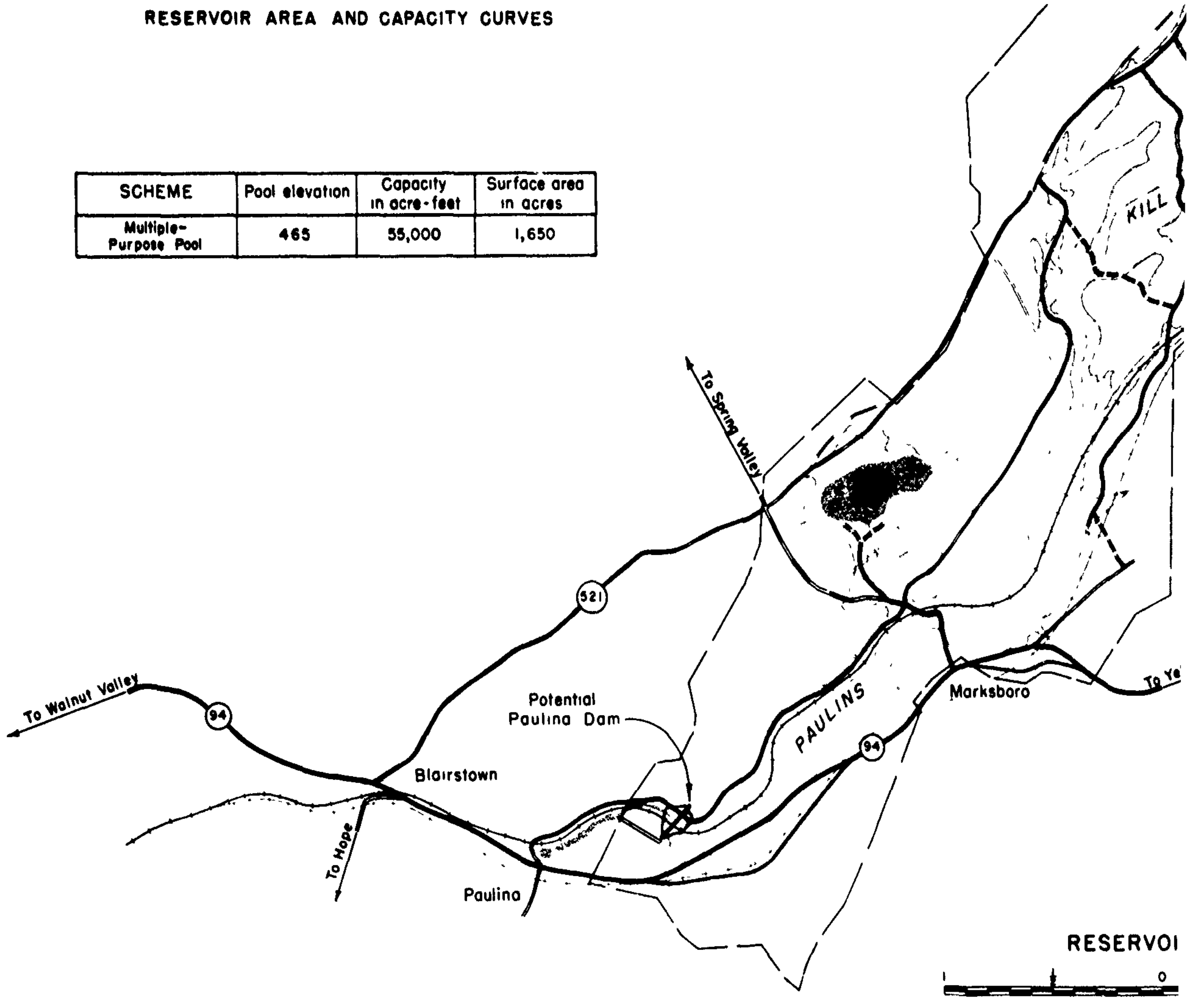
e. The reservoir created by this dam (up to the spillway crest, elevation 465 feet) would be 115 feet deep at the dam and would extend 14 miles upstream. It would be necessary to relocate portions of a state highway, several county roads and a railroad. A transmission line across the reservoir would require reinforcing. No commercial mineral desposits exist in the reservoir area.

f. The estimated cost of the development, as described, is 23.1 million dollars. This estimate includes 5.3 million dollars to acquire the reservoir land area to preserve it for future use and 6.9 million dollars of specific recreation costs comprised of 3.5 million dollars for land and 3.4 million dollars for recreation facilities. The remaining 10.9 million dollars is the estimated cost of the dam and appurtenant works, relocations, and reservoir clearing if the project were constructed as proposed herein.



RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	465	55,000	1,650



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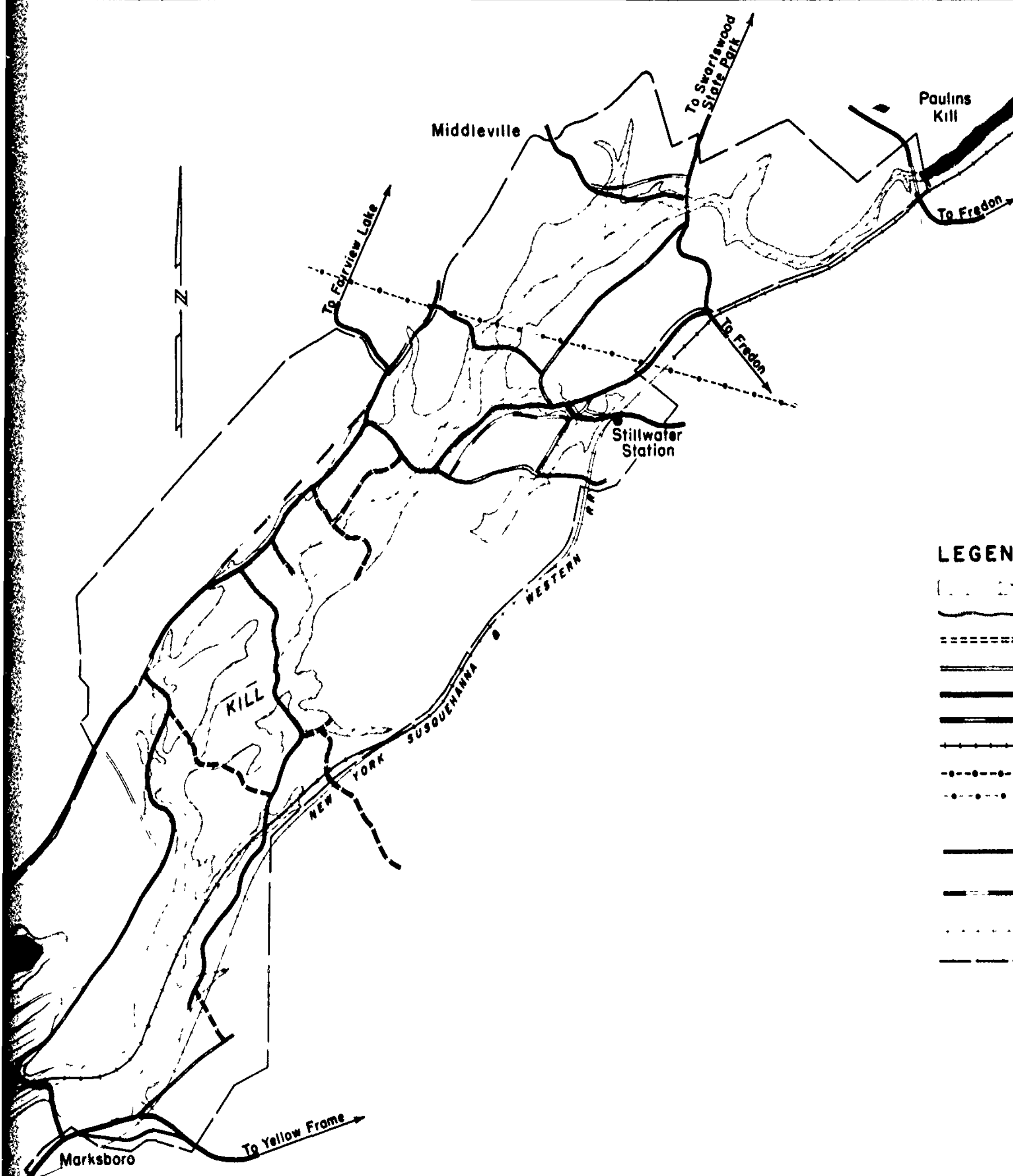
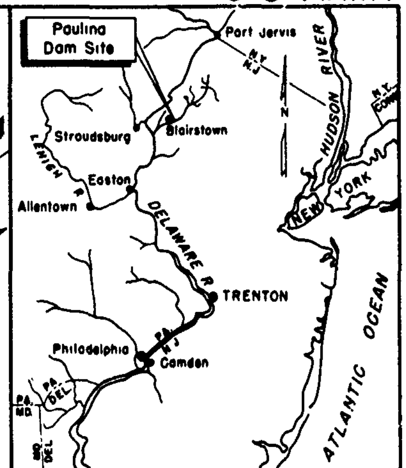




LOCATION MAP

SCALE

LEGEND

- Multiple-Purpose Pool El. 465
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Proposed Reinforced Power Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Railroad
- Land Acquisition for Recreation Development

RESERVOIR MAP

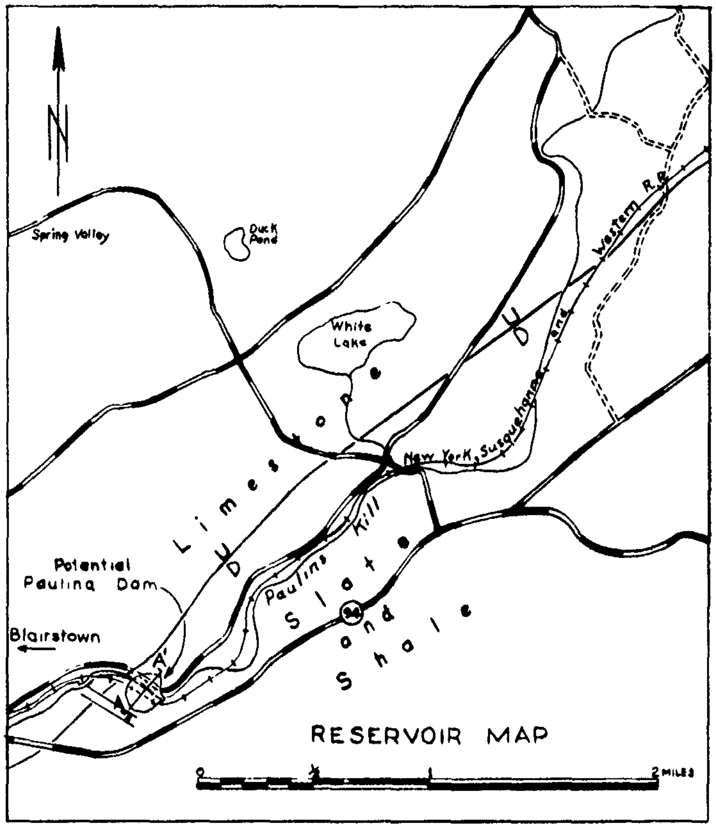
1 0 1 MILE

REVIEW REPORT DELAWARE RIVER BASIN

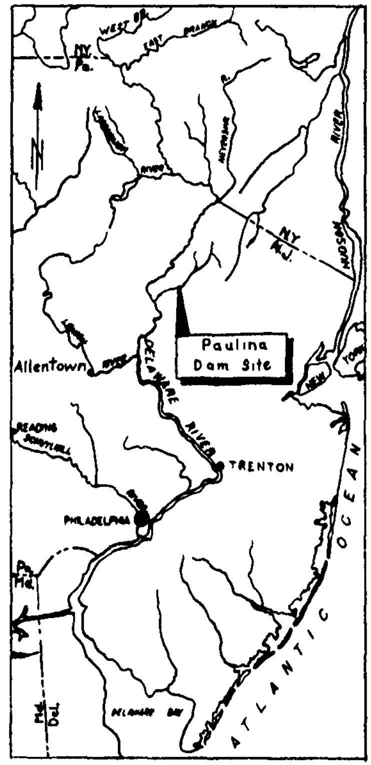
PAULINA PROJECT

In 1 Sheet	Scale as Shown
Corps of Engineers Philadelphia, Pa	Philadelphia District June 1960
Drawer No 228	File No. 29103

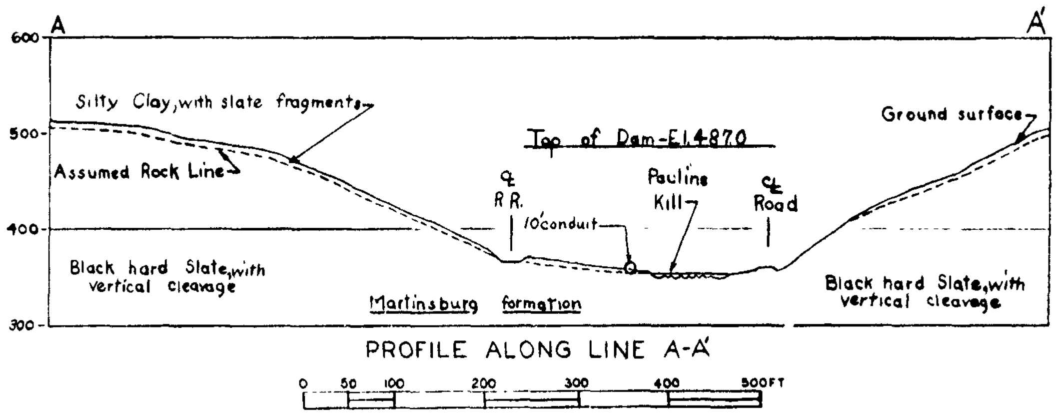
CORPS OF ENGINEERS U. S. ARMY



RESERVOIR MAP



LOCATION MAP



PROFILE ALONG LINE A-A'

NOTES:

1. U/D shows fault, from Geologic Map of New Jersey, by J.V. Lewis and H. B. Kümmel.
2. U-represents upthrown side of fault, and D-represents downthrown side of fault.
3. No borings made because of rock outcrop and thin cover of overburden.
4. Reservoir underlain by Kittatinny limestone on upthrown side of fault and Martinsburg slate on downthrown side of fault.

REVIEW REPORT DELAWARE RIVER BASIN

PAULINA PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa.

Scales as Shown
Philadelphia District
18 Jan. 60

Drawer No. 228

File No. 21089

40. <u>Pequest Project</u>

a. The Pequest project fully developed would provide facilities for water supply, recreation and other purposes. The full development would be required some time after the year 2010. To preserve the site, it is proposed that land be acquired as it becomes available and be put to immediate recreation purposes.

b. The dam would be located on the Pequest River about seven miles above its mouth at the Delaware River and 2.5 miles northeast of Oxford, New Jersey. The drainage area above this site is 100 square miles. Data on basic dimensions of the project at its ultimate development are as follows:

<u>Capacity</u>
Long term, 41,000 ac.-ft., stream bed to elevation 507

<u>Elevations</u>

Top of dam, 529	Outlet, upstream invert, 419
Spillway crest, 507	Stream bed at dam, 417

<u>Area</u>
Reservoir at elevation 507, 1,260 acres

c. At the dam site the river flows in a valley cut into Cambro-Ordovician limestone near the contact with Cambrian quartzite, resting on pre-Cambrian gneiss. On the right (north) abutment shallow pre-Wisconsin glacial drift mantles the bedrock for a short distance up the abutment where gneiss outcrops. On the left (south) abutment limestone outcrops just above the flood plain and intermittently up the abutment which is largely mantled by pre-Wisconsin glacial drift. The flood plain at the axis is covered by 18 feet of recent alluvium. Many springs discharge into the river at this point and bore hole Number 1 had an artesian flow from the cavernous limestone. Geologic data are shown on plate 42.

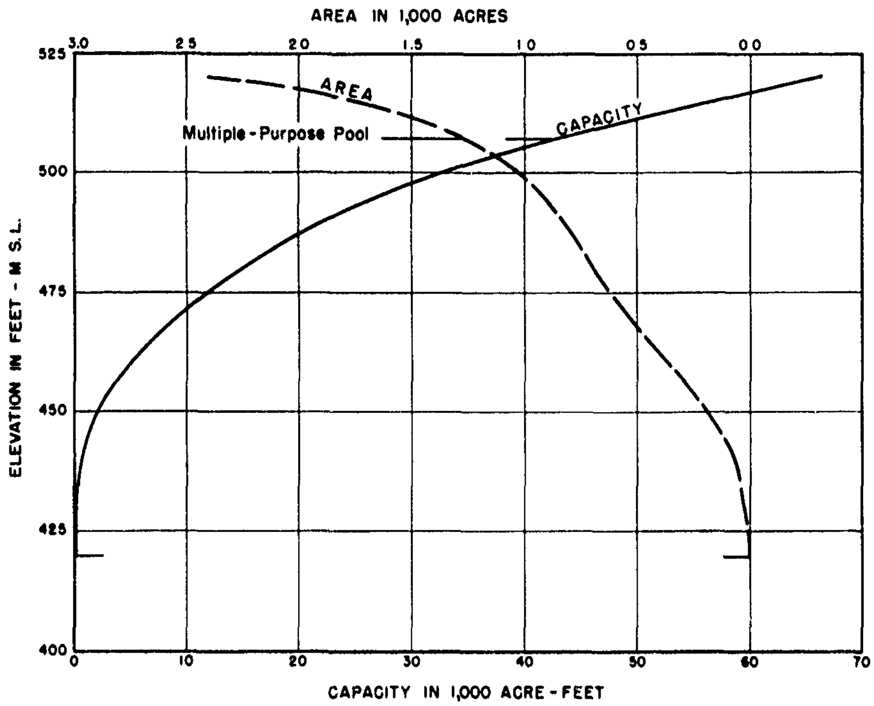
d. The dam for which the cost estimate was made would be an earth embankment with a 30-foot wide top at elevation 529 feet (approximately 112 feet high), 1,635 feet long. Extensive grouting for safety and leakage control would be required. A 150-foot wide spillway would pass flood waters over the right abutment around the end of the embankment. An eight-foot diameter concrete conduit would carry flows for diversion during construction and controlled reservoir releases thereafter.

e. The reservoir created by this dam (up to the spillway crest, elevation 507 feet) would be 90 feet deep at the dam and would extend about 4.5 miles upstream. It would make necessary the

relocation of one community, about six miles of railroad, a Federal highway and several county roads as well as reinforcement of a high tension powerline. There are no commercially valuable mineral deposits within the reservoir area.

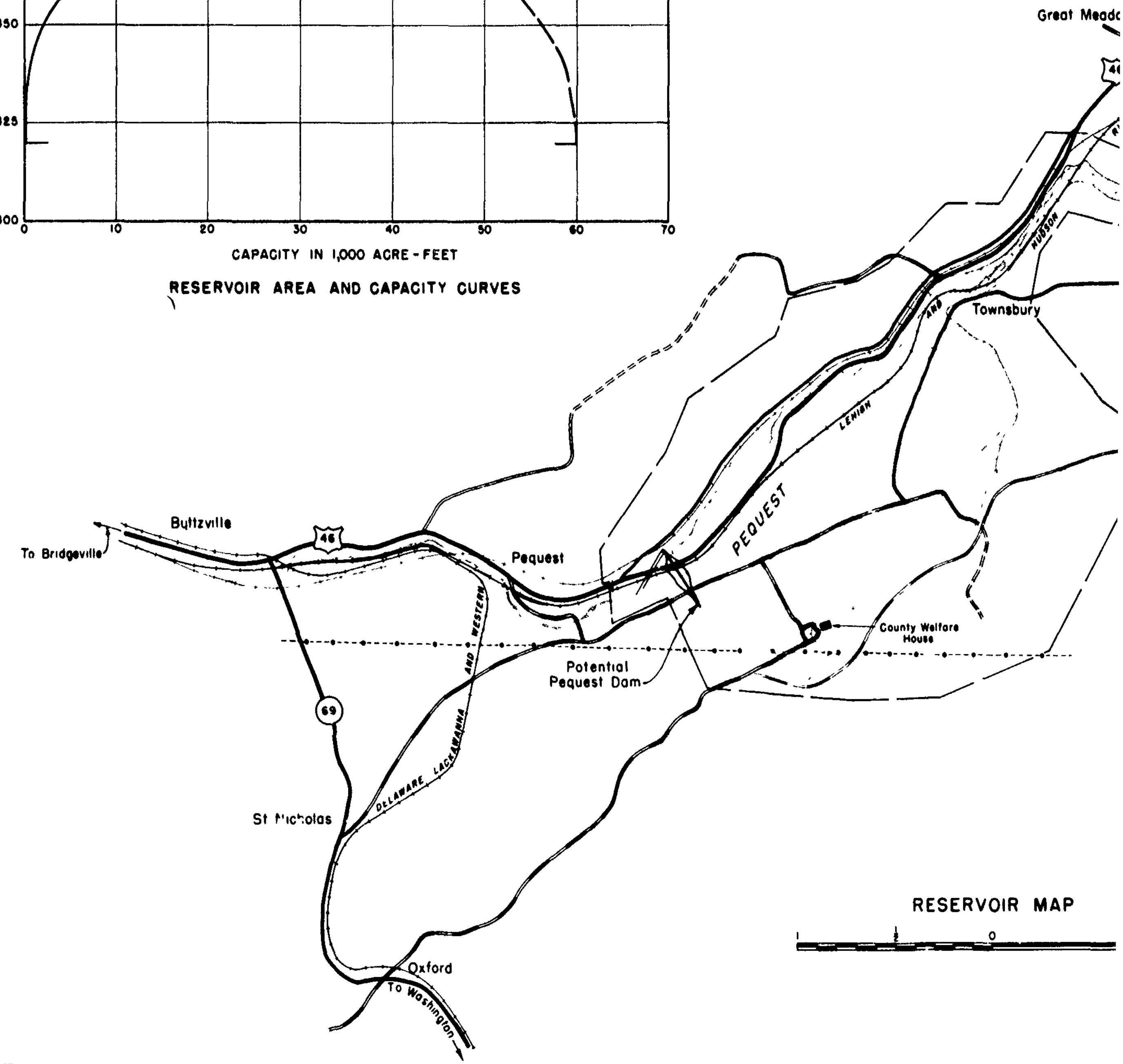
f. The estimated cost of the development, as described, is 16.3 million dollars. This estimate includes 2.0 million dollars to acquire the reservoir land area to preserve it for future use and 3.0 million dollars of specific recreation costs comprised of 1.2 million dollars for land and 1.8 million dollars for recreation facilities. The remaining 11.3 million dollars is the estimated cost of the dam and appurtenant works, relocations, and reservoir clearing if the project were constructed as proposed herein.

CORPS OF ENGINEERS



RESERVOIR AREA AND CAPACITY CURVES

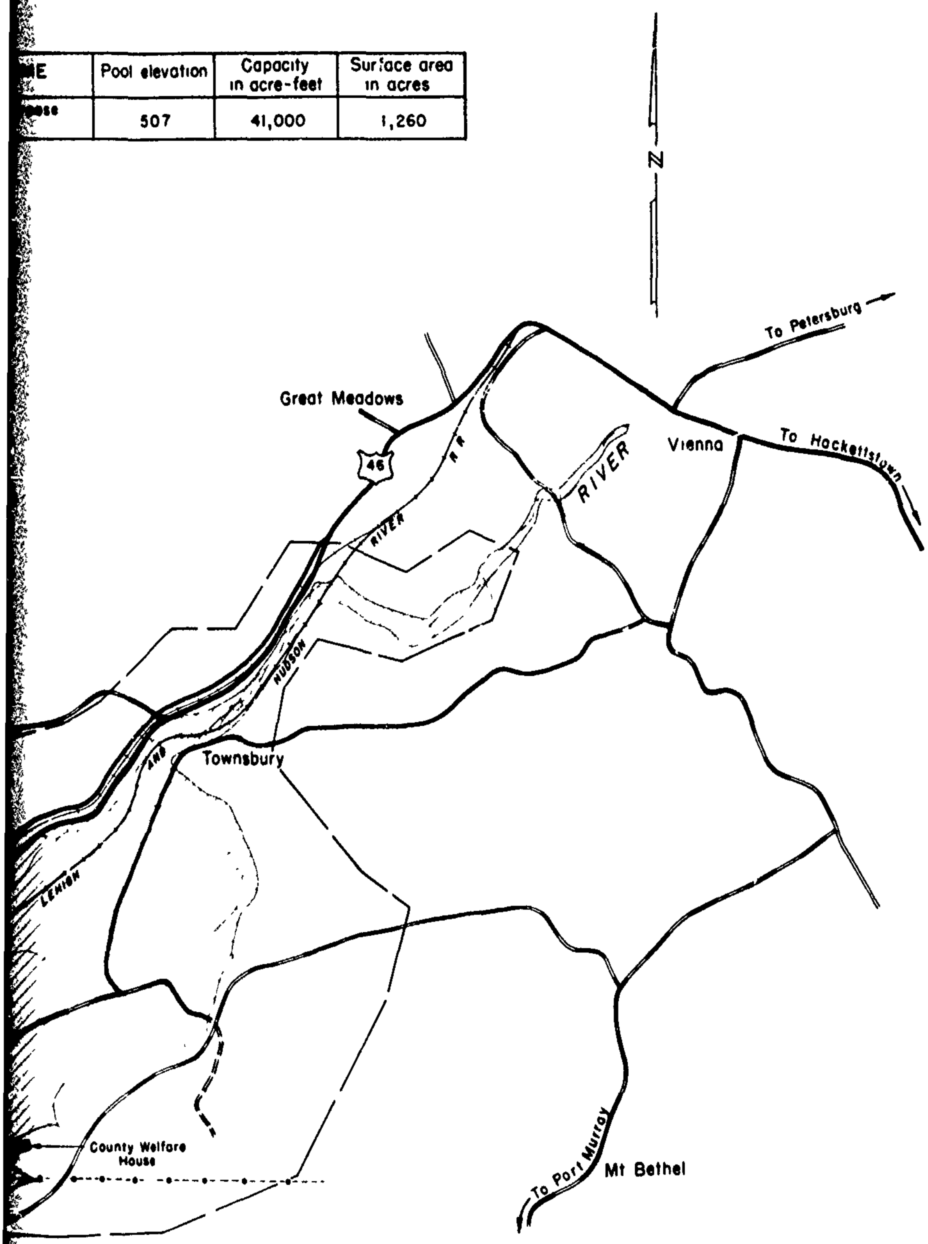
SCHEME	Pool elevation	Capacity in acre-feet	Surf… in…
Multiple-Purpose Pool	507	41,000	

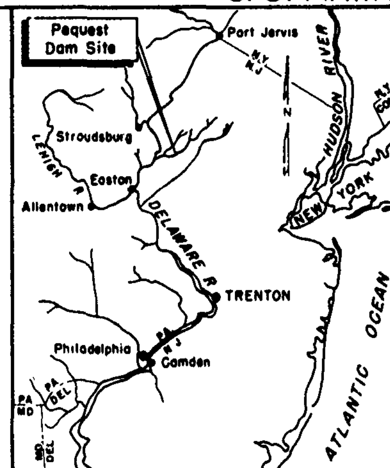


RESERVOIR MAP

U. S. ARMY

...E	Pool elevation	Capacity in acre-feet	Surface area in acres
...ose	507	41,000	1,260





LOCATION MAP

SCALE:

LEGEND

- Multiple-Purpose Pool Elevation 507
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Railroad
- Existing Power Line
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Relocated Railroad
- Proposed Reinforced Power Line
- Land Acquisition for Recreation Development

REVIEW REPORT DELAWARE RIVER BASIN

PEQUEST PROJECT

RESERVOIR MAP

0 1 MILE

In 1 Sheet

Scale as Shown

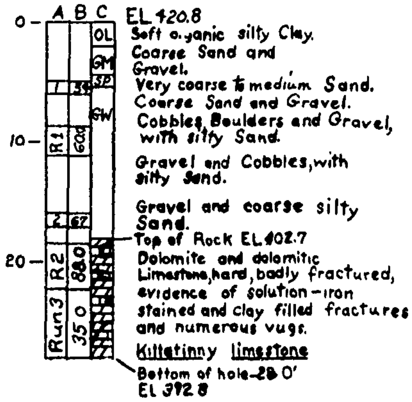
Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

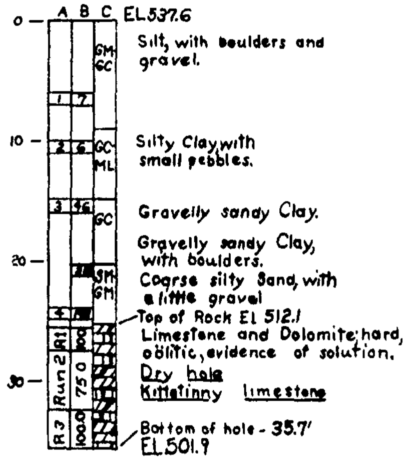
Drawer No 228

File No 29106

CORPS OF ENGINEERS



B.H.#1



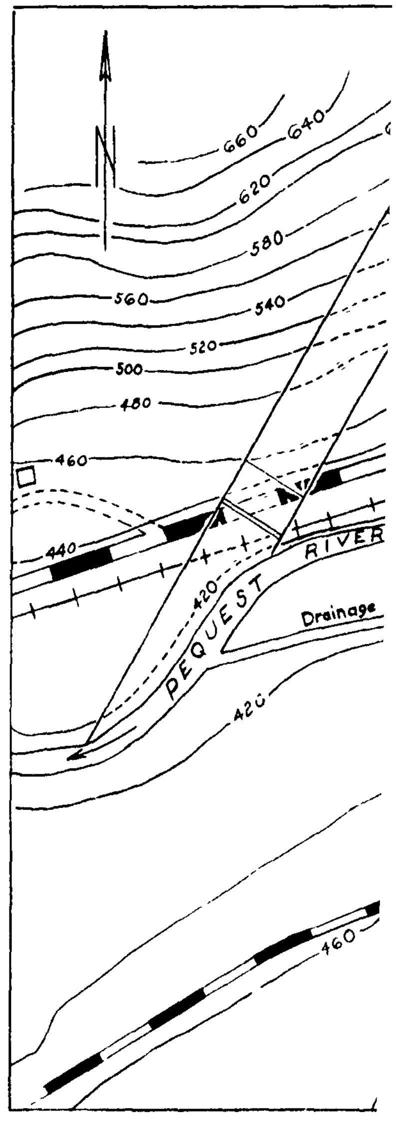
B.H#2

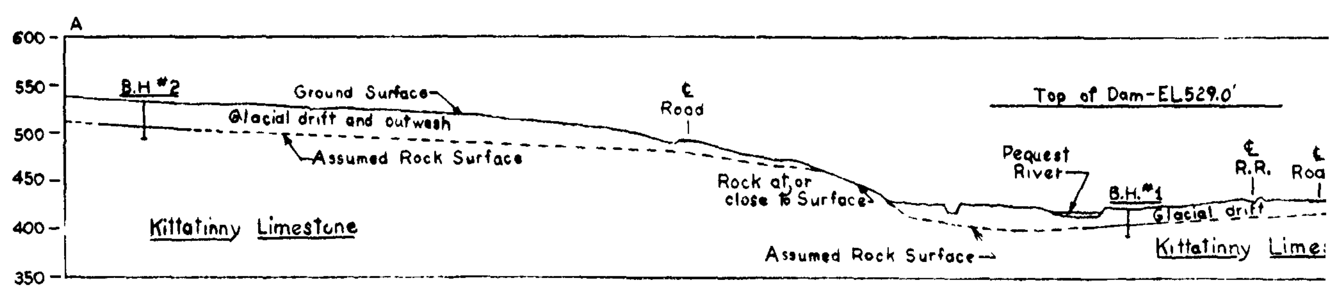
NOTES.

1. Descriptions of materials encountered in borings are based on visual inspection of cuttings, spoon and core samples.
2. Numbers in column "A" indicates drive samples or core run number
3. Column "B" indicates blow count for one (1) foot penetration by standard split spoon using 140 lb. weight with a 30 inch drop, or percent recovery for the interval shown.
4. Column "C" indicates field classification of the materials encountered, using the Unified Soils Classification System symbols and graphic rock symbols.
5. All elevations based on mean sea level.
6. Water conditions encountered in hole number one (1) are as follows:

—Artesian Flow—	—Head—
5.0 ft. – 1 gal/min	325 ft.
15.6 ft. – 10 gal/min.	"
17.0 ft. – 15 gal/min.	"
22.2 ft. – 40 gal./min.	"
28.0 ft. – 60 gal./min.	"

7. Work performed by Layne, New York Co., Inc. during April, 1959.

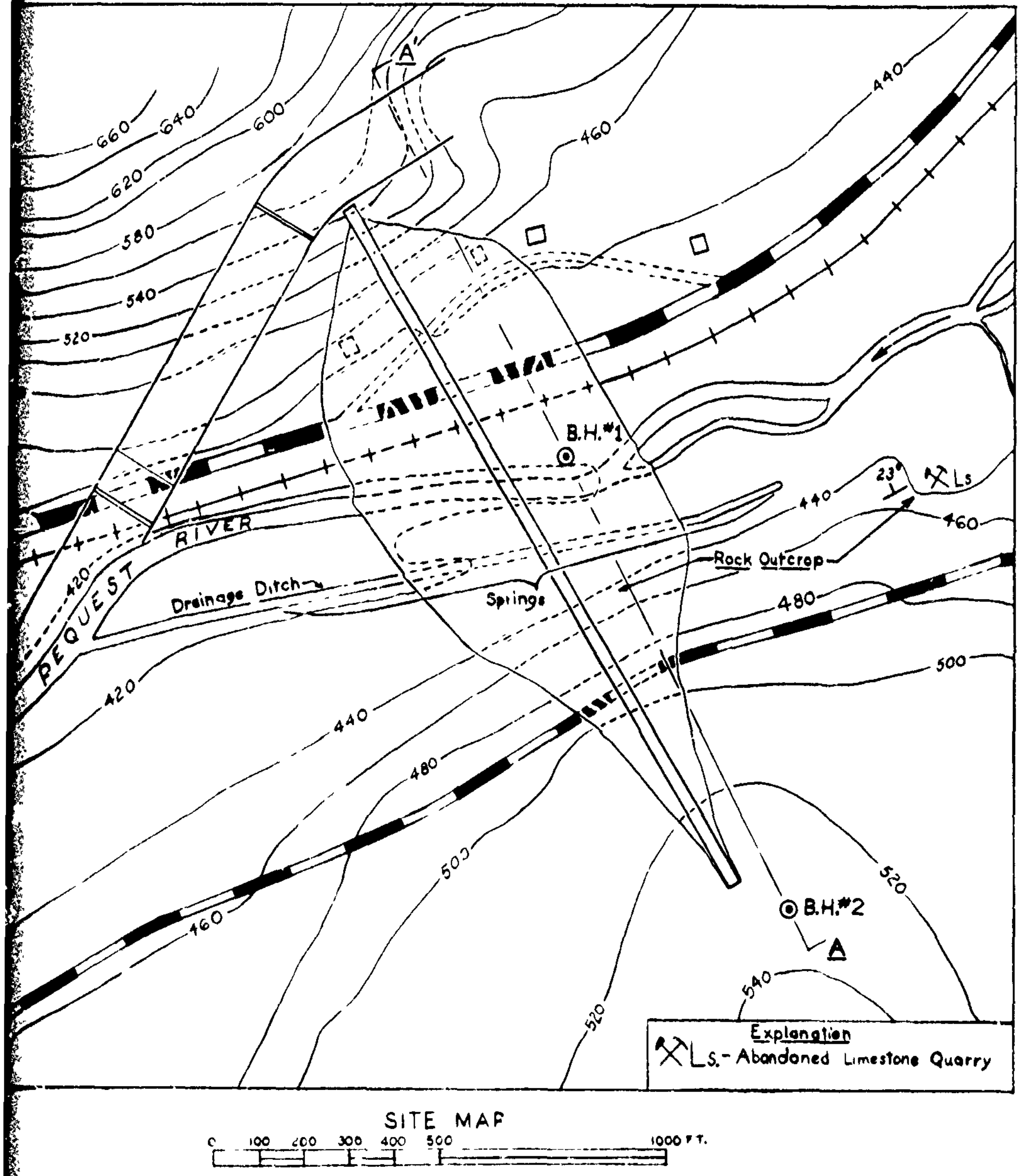




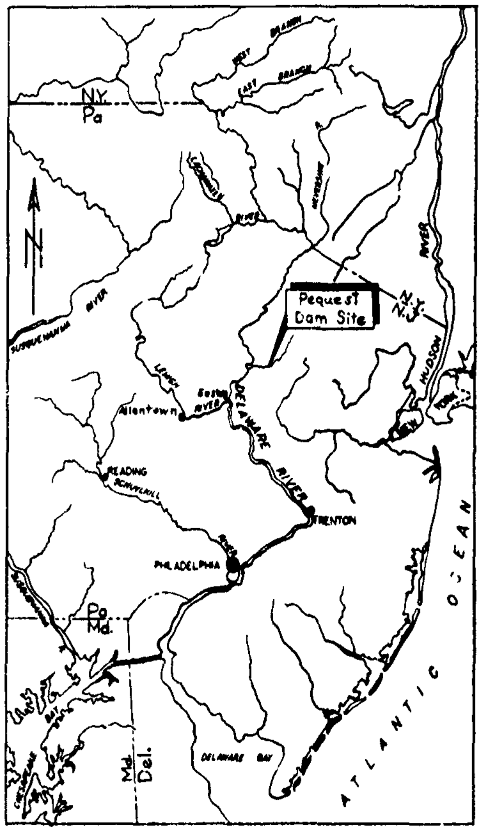
PROFILE ALONG LINE A-A'

0 50 100 200 300 400 500 FT.

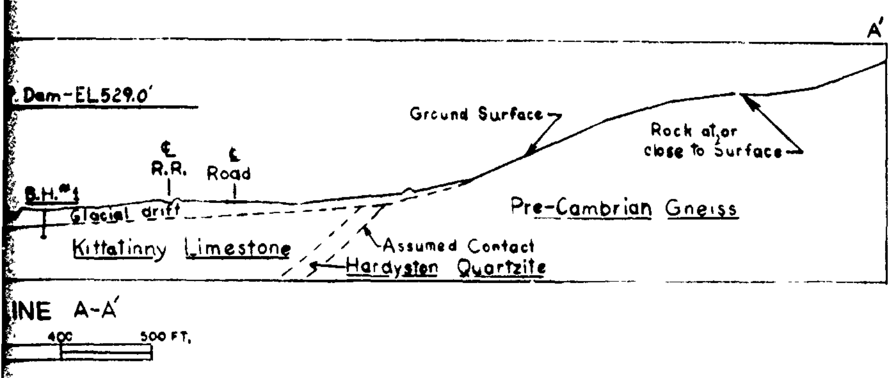
U.S. ARMY



SITE MAP



LOCATION MAP



INE A-A'

REVIEW REPORT DELAWARE RIVER BASIN

PEQUEST PROJECT
GEOLOGIC DATA

In 1 Sheet
Corps of Engineers
Philadelphia, Pa.

Scales as Shown
Philadelphia District
8 Feb. 60

Drawer No 228

File No. 29090

PLATE 42

41. Tohickon Project

2. The Tohickon project fully developed would provide facilities for water supply, recreation and other purposes. The full development would be required some time after the year 2010. To preserve the site, it is proposed that land be acquired as it becomes available and be put to immediate recreation purposes.

b. The dam would be located across Tohickon Creek about one mile southwest of Ottsville, Pennsylvania. The drainage area above this site is 75 square miles. Data on basic dimensions of the project at its ultimate development are as follows:

Capacity
Long term, 31,500 ac.-ft., stream bed to elevation 388

Elevations
Top of dam, 403
Spillway crest, 388
Outlet, upstream invert, 312
Stream bed at dam, 307

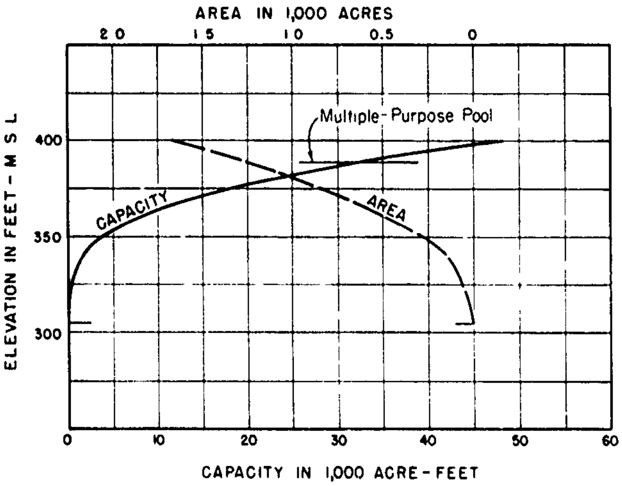
Area
Reservoir at elevation 388, 1,250 acres

c. At the dam site the creek has cut a nearly vertical bank on the left (north) side of the valley through Triassic sandstone and silty shale. No rock outcrops on the right abutment. Soil cover in the valley, as found by one drill hole shown on the attached drawing, is 13-1/2 feet of alluvial deposits. The residual soil cover on the adjacent hills is of varying thickness, and consists of silty clay and sandy clay with frequent shards of partly weathered shale.

d. The dam, for which the cost estimate was made, would be a concrete gravity dam up to elevation 403 (96 feet high) 1,080 feet long with an overflow spillway 600 feet long at a crest elevation of 388. Course aggregate for concrete could be secured from an active quarry 5 miles southwest of the site or from any of several other quarries within a 15 mile radius. The screenings from one of these quarries might prove acceptable, after test, for use as fine aggregate in the concrete. If not, the fine aggregate would have to be obtained at Riegelsville, 9 miles from the site, or from one of numerous sand pits in southeast Bucks County, about 20 miles away. Sluices and bypass pipes through the concrete at low levels would provide for reservoir releases. Diversion would be accomplished over low monoliths in the concrete overflow section.

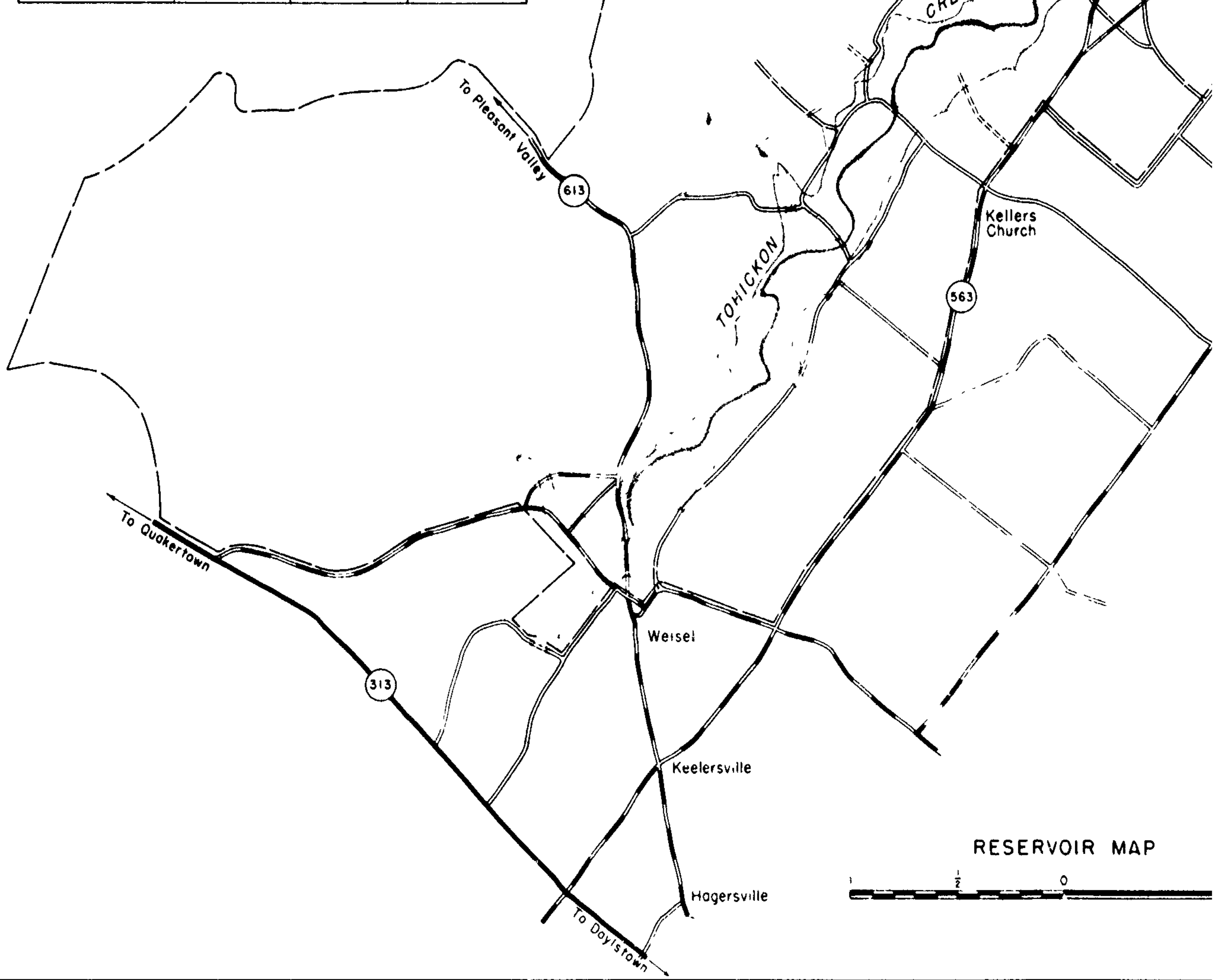
e. The reservoir created by this dam (up to the spillway crest, elevation 388) would be 81 feet deep at the dam and would extend about 6-1/2 miles upstream. It would make necessary the relocation and raising of county roads, two state highways and relocation of the village of Tohickon. There are no commercially valuable mineral deposits in the reservoir area.

f. The estimated cost of the development, as described, is 21.8 million dollars. This estimate includes 1.0 million dollars to acquire the reservoir land area to preserve it for future use and 11.2 million dollars of specific recreation costs comprised of 6.9 million dollars for land and 4.3 million dollars for recreation facilities. The remaining 9.6 million dollars is the estimated cost of the dam and appurtenant works, relocations, and reservoir clearing if the project were constructed as proposed herein.



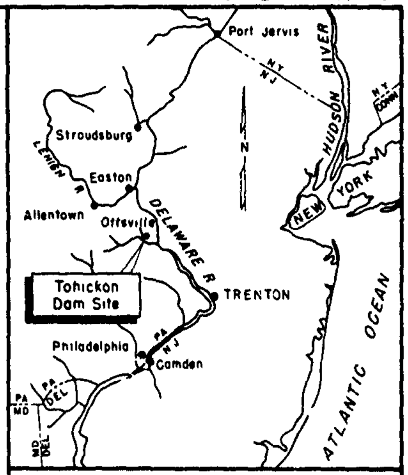
RESERVOIR AREA AND CAPACITY CURVES

SCHEME	Pool elevation	Capacity in acre-feet	Surface area in acres
Multiple-Purpose Pool	388	31,500	1,250



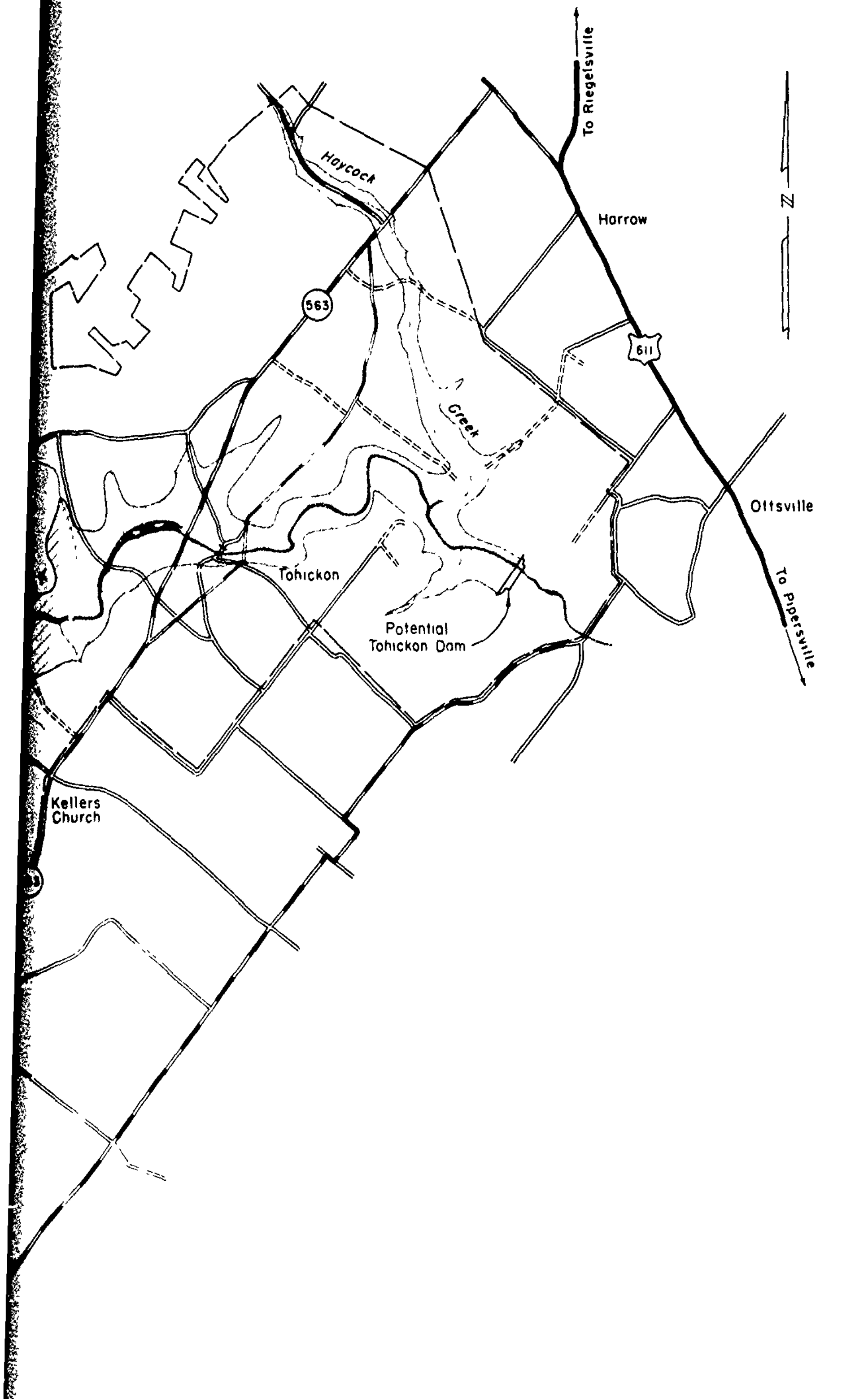
RESERVOIR MAP

U S. ARMY



LOCATION MAP

SCALE



RESERVOIR MAP

0 1 MILE

LEGEND

- Multiple-Purpose Pool El. 388
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Proposed Relocated Graded Road
- Proposed Relocated Secondary Hard Surface Road
- Land Acquisition for Recreation Development

REVIEW REPORT DELAWARE RIVER BASIN

TOHICKON PROJECT

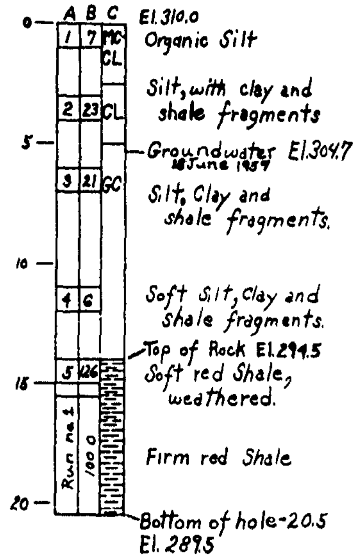
In 1 Sheet | Scale as Shown

Corps of Engineers
Philadelphia, Pa

Philadelphia District
June 1960

Drawer No 228 | File No 29110

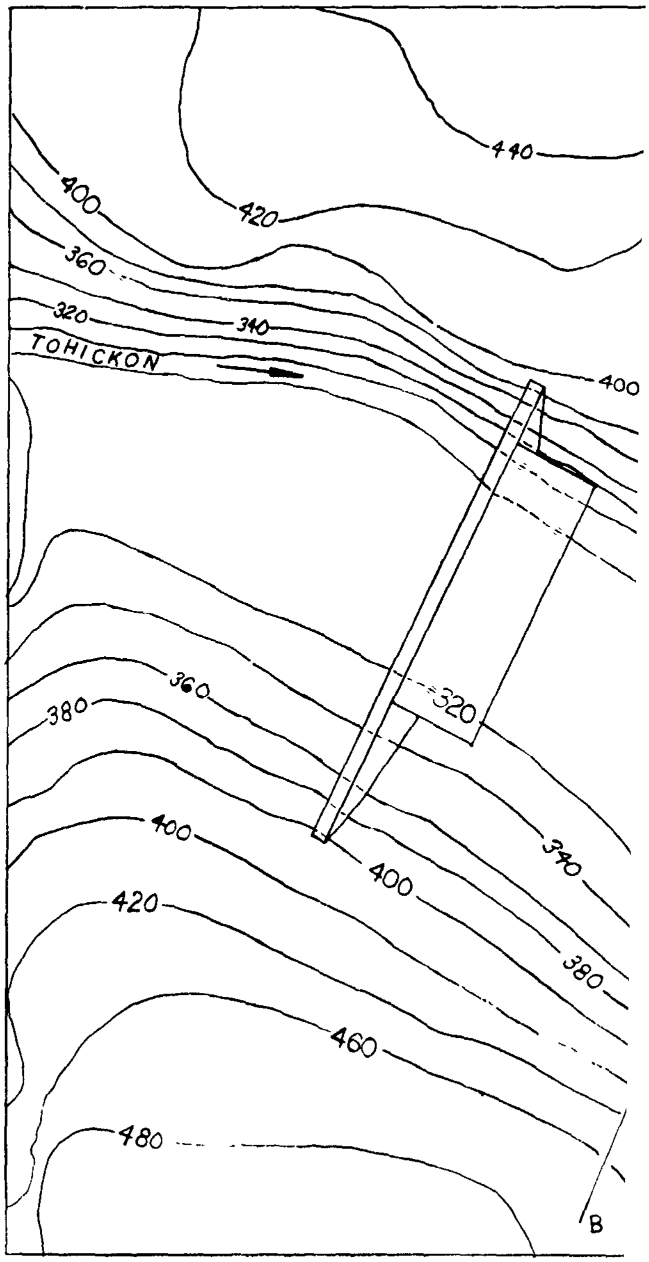
CORPS OF ENGINEERS

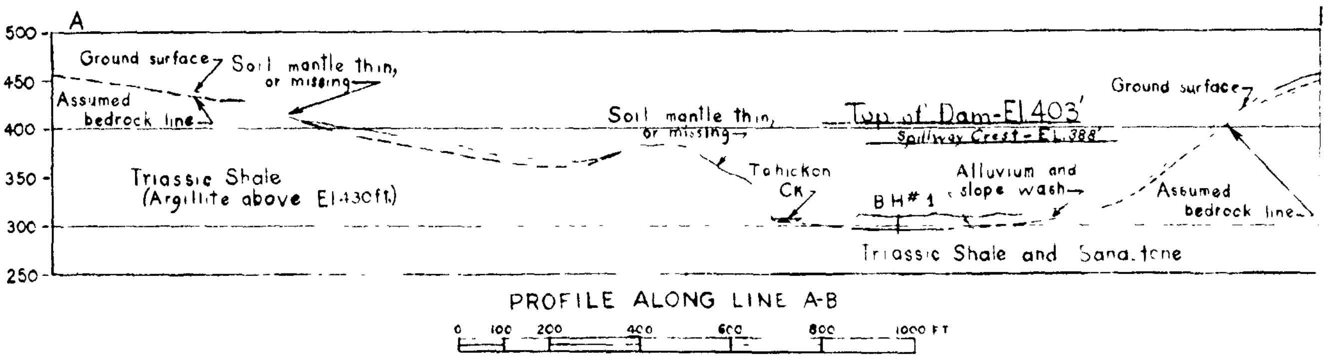


BH #1

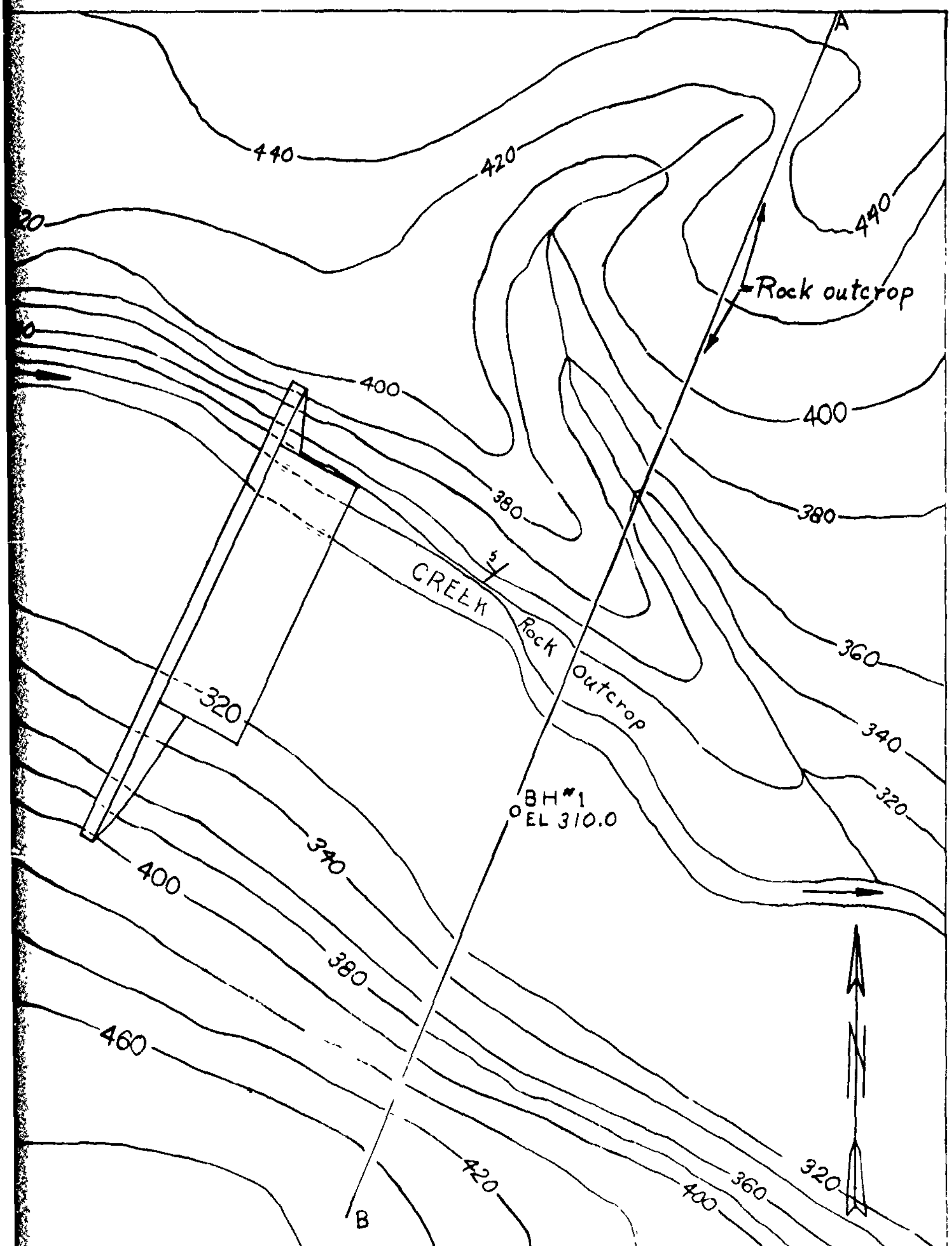
NOTES:

1. Descriptions of materials encountered in borings are based on visual inspection of spoon samples and core.
2. Column "A" refers to the sample number or core run number
3. Column "B" refers to the number of blows a 140 lb. hammer dropping 30 inches required to push the sampling spoon one (1) foot into the materials encountered or the percent recovery of a specified core run
4. Column "C" is a field classification using the Unified Soils Classification System symbols, and graphic rock symbols.
5. All elevations based on mean sea level datum
6. Boring by Sprague and Henwood, Inc., in June 1957
7. 57- indicates direction of strike and dip of bed in degrees.



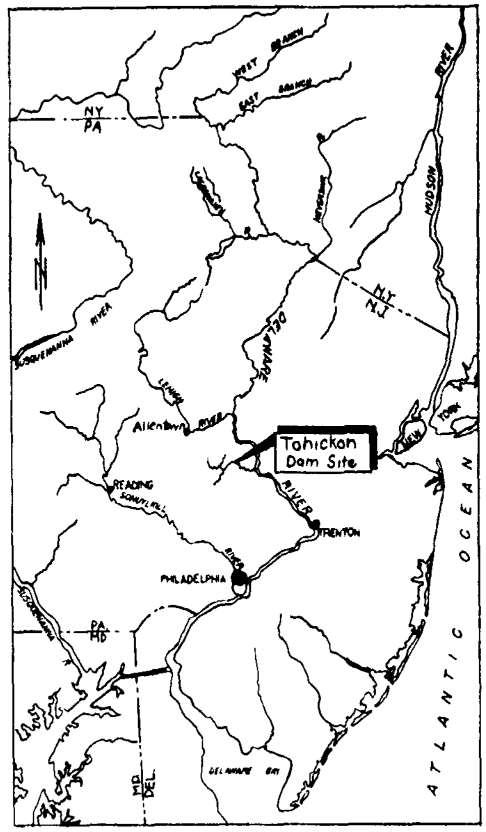


U.S. ARMY

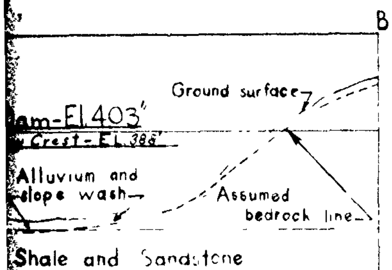


SITE MAP

0 100 200 300 400 500 1000 FT



LOCATION MAP



REVIEW REPORT DELAWARE RIVER BASIN

TOHICKON PROJECT
GEOLOGIC DATA

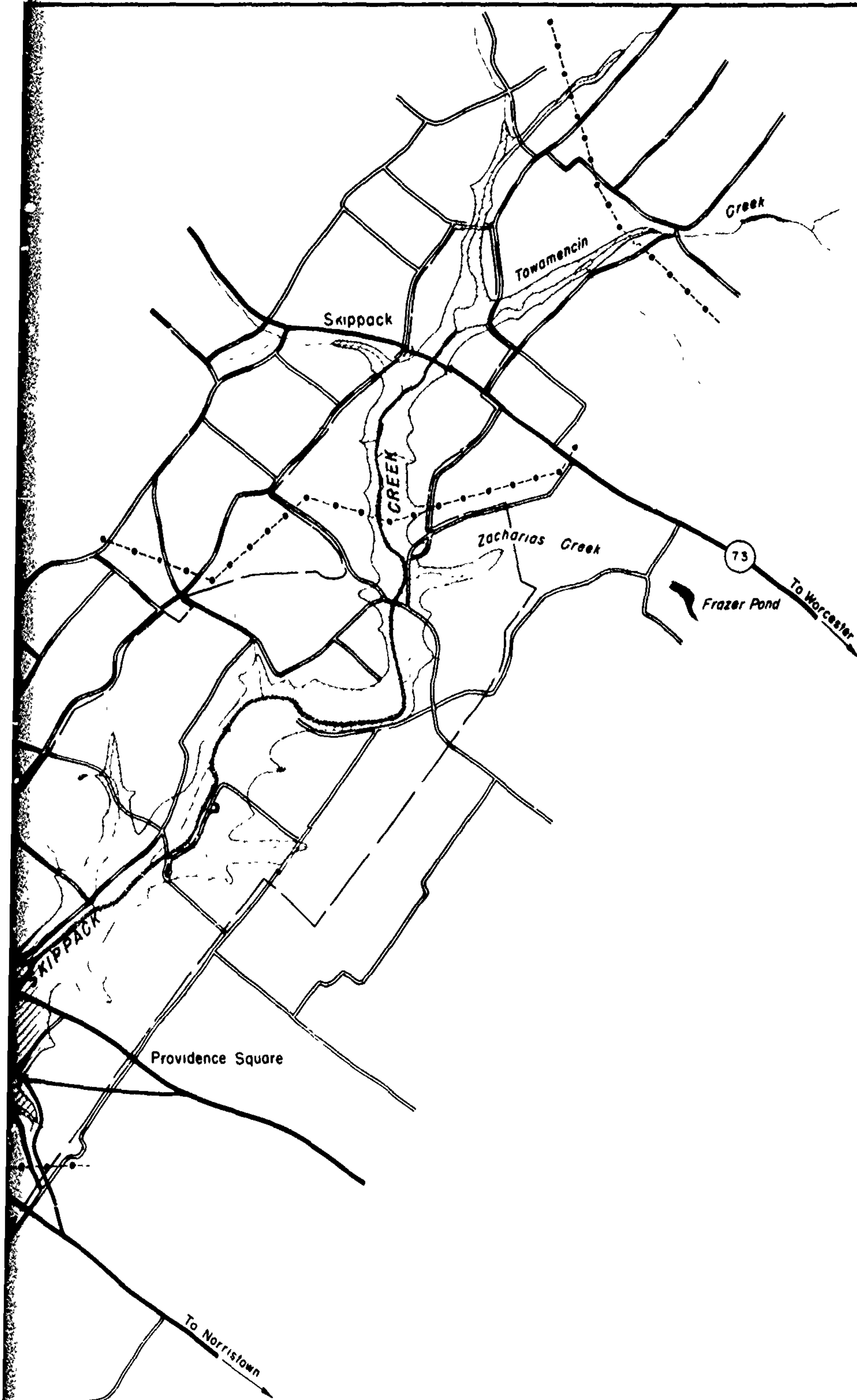
In 1 Sheet
Corps of Engineers
Philadelphia, Pa

Scales as Shown
Philadelphia District
14 Jan 60

Drawer No 228

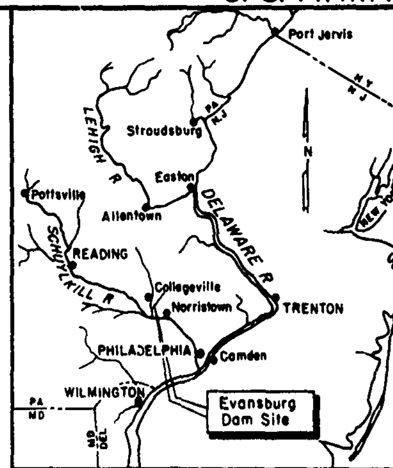
File No 28913

PLATE 44



RESERVOIR MAP

1 ½ 0 1 MILE



LOCATION MAP

SCALE

LEGEND

- Multiple-Purpose Pool El. 166
- Existing Stream
- Dirt Road
- Graded Road
- Hard Surface, Heavy Duty Road
- Secondary Hard Surface Road
- Existing Power Line
- Proposed Relocated Graded Road
- Proposed Relocated Hard Surface Heavy Duty Road
- Proposed Relocated Secondary Hard Surface Road
- Proposed Reinforced Power Line
- Land Acquisition for Recreation Development

REVIEW REPORT DELAWARE RIVER BASIN

EVANSBURG PROJECT

In 1 Sheet	Scale as Shown
Corps of Engineers Philadelphia, Pa	Philadelphia District June 1960
Drawer No 228	File No 29116